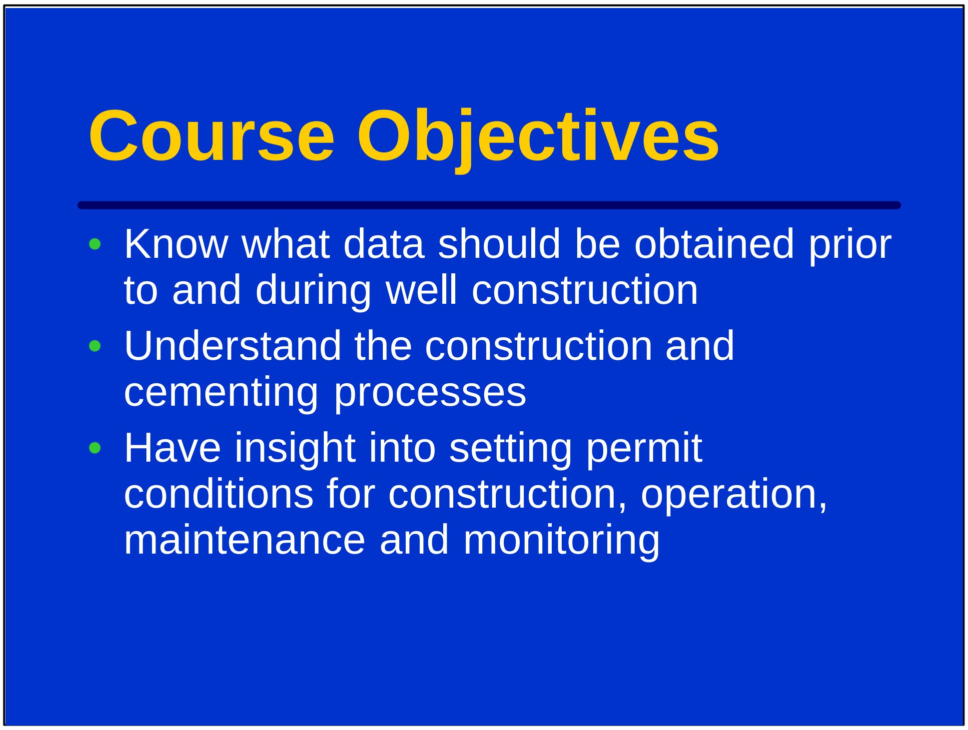
# Introduction to UIC Permitting

# Course Objectives

- Understand the key elements required for UIC permits, including:
  - USDW identification and exemptions
  - Area of review
  - Construction and testing procedures
  - Operational and maintenance conditions
  - Financial assurance documentation
- Course does not cover technical issues related to hazardous waste disposal
- For Class V wells, course is most relevant to deeper, permitted wells

- This course is intended to acquaint technical personnel with basic permitting components and issues. The course has been designed based on the required elements of the EPA permit application and attachments, which are completed and submitted by the applicant.
  - Although the principles of permitting are the same, there are specific technical issues related to permitting hazardous waste disposal wells. They are not discussed in this course.
  - At the opposite end of the spectrum, there are also specific technical issues related to Class V wells. This training is most relevant to deeper, permitted Class V wells.
- At the course's completion, you will have been introduced to key elements for which you will be responsible in reviewing permit applications and developing permit conditions.
- This course will provide resources for future reference as you work with more experienced permit writers to enhance your skills and prepare to make decisions that protect critical underground sources of drinking water.

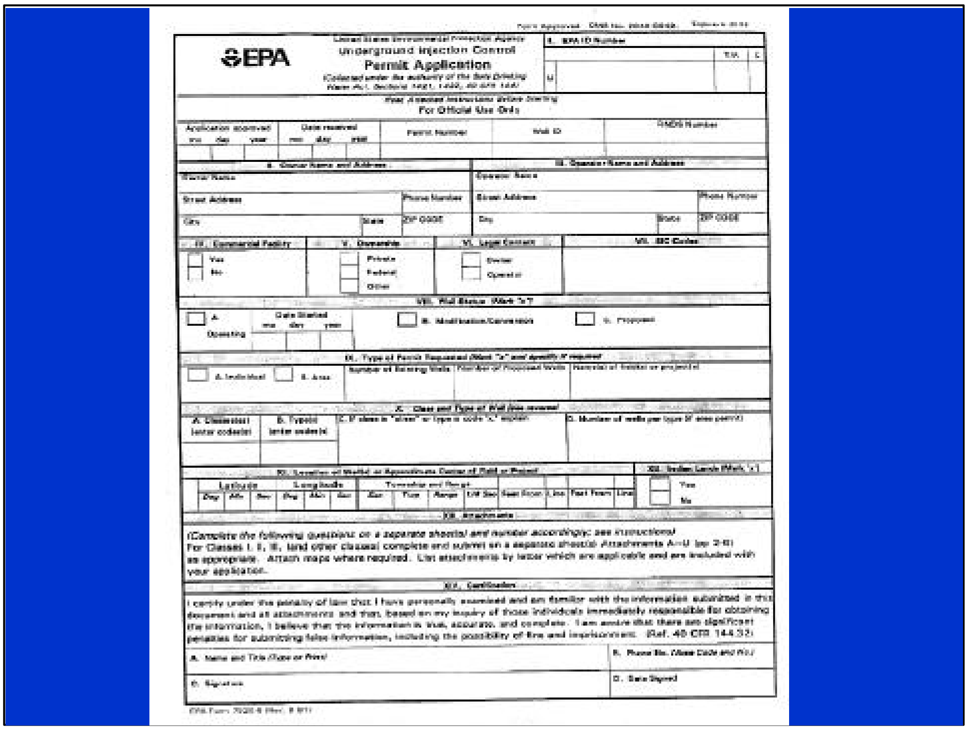



- In order to achieve these objectives, the instructors will:
  - Present technical information specific to permitting issues and writing permits;
  - Explain the regulatory basis for the various key permitting elements;
  - Discuss the relevance of the regulations to the various well classes and protection of USDWs;
  - Indicate the availability of options or alternative methods for solving permitting problems;
  - Present resources available to assist you as you review permit applications; and
  - Provide a forum for sharing permit strategies among UIC professionals.

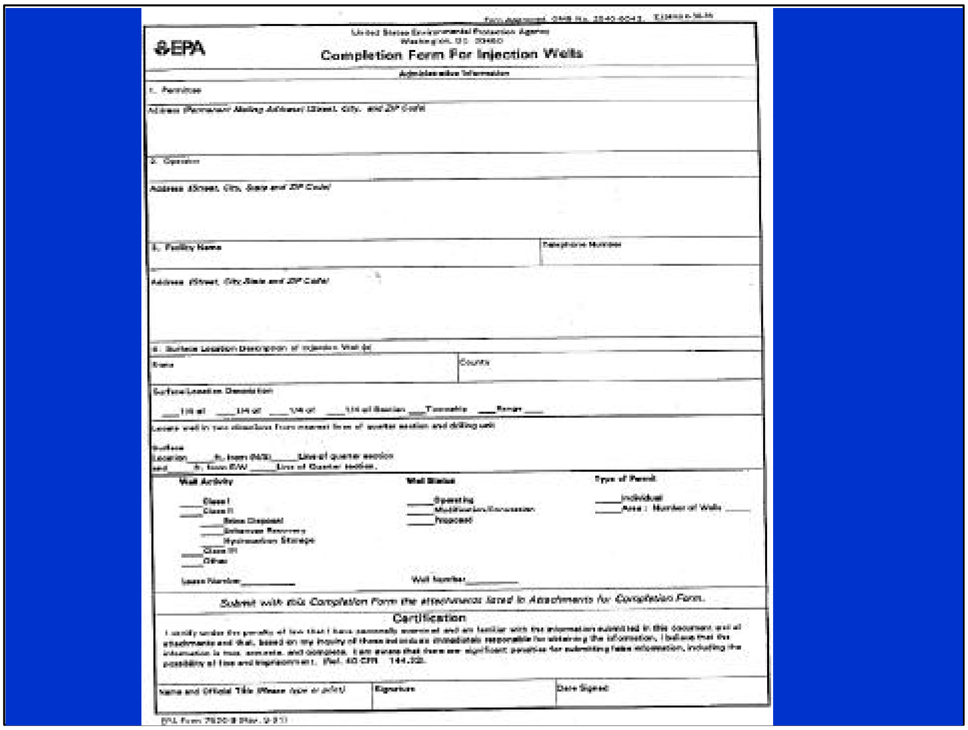
# Course Objectives

- Know plugging and abandonment requirements and how to address well failures
- Understand financial assurance requirements
- Explain public participation in the UIC permitting process

- The course objectives are focused on giving you a concise but thorough review of these key permitting elements.
- This course manual and the supporting materials in the appendices should be used as references as you review applications and develop permits in the future.




- The UIC Permit Application Form marks the beginning of the permit process (filled in by the operator, of course).



EPA

United States Environmental Protection Agency
Washington, DC 20460

Completion Form For Injection Wells

Administrative Information

1. Permittee

Address (Permanent Mailing Address) (Street, City, and ZIP Code)

2. Operator

Address (Street, City, State and ZIP Code)

3. Facility Name | Telephone Number

Address (Street, City, State and ZIP Code)

4. Surface Location Description of Injection Well(s)

State | County

Surface Location Description

___ 1/4 of ___ 1/4 of ___ 1/4 of ___ 1/4 of Section ___ Township ___ Range ___

Locate well in two directions from nearest lines of quarter section and drilling unit

Surface Location ___ ft. from (N/S) ___ Line of quarter section
and ___ ft. from (E/W) ___ Line of Quarter section.

Well Activity
___ Class I
___ Class II
___ Brine Disposal
___ Enhanced Recovery
___ Hydrocarbon Storage
___ Class III
___ Other

Well Status
___ Operating
___ Modification/Conversion
___ Proposed

Type of Permit
___ Individual
___ Area : Number of Wells ___

Lease Number ___ Well Number ___

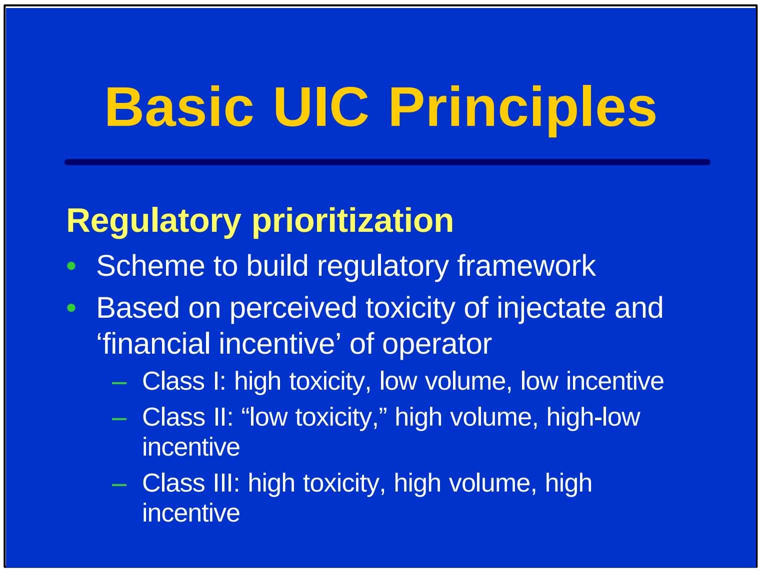
*Submit with this Completion Form the attachments listed in Attachments for Completion Form.*

Certification

Name and Official Title (Please type or print) | Signature | Date Signed

EPA Form 7520-9

- The Completion Form and required attachments for Injection Wells usually marks the end of the permitting process. During this course, we are going to talk about everything in-between.



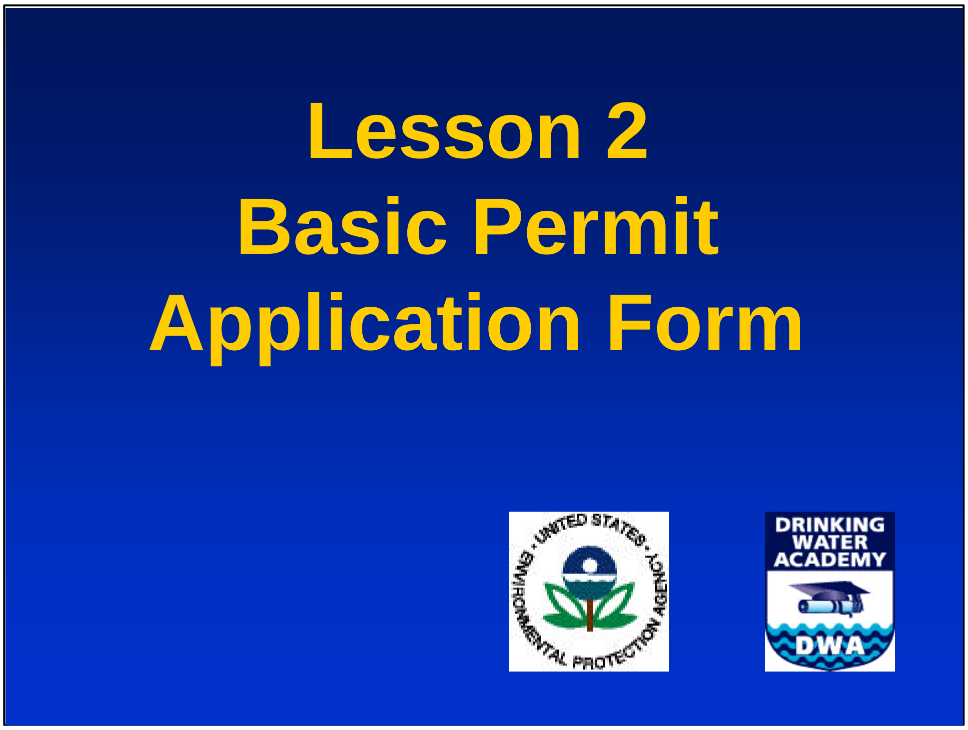

- One of the underlying principles of the UIC program is the concept of regulatory prioritization. This concept was developed by EPA in 1976 to help in developing a regulatory scheme for the regulation of the injection universe, as mandated by the Safe Drinking Water Act of 1974. This philosophy of regulatory development was necessary both to categorize the potential threat to USDWs presented by different types of injection wells, and to ensure the application of the appropriate level of regulatory scrutiny. The UIC regulatory framework had to address not only existing injection wells, but also injection practices yet to be developed. This scheme of prioritization was not only the basis for the UIC well classes, but also is one of the principles that guides the everyday application of the program.
- The underlying factors of regulatory prioritization were determined to be the toxicity of the waste and the financial incentive that the operator might have to keep his well in good operating condition and to control the fate of his injectate. The well classes were created to reflect the level of oversight that EPA thought appropriate.
  - Class I wells involved the most-toxic of wastes and the least financial incentive for the operators (out of sight, out of mind), although the projected volume of injectate was small.
  - Class II wells featured a vast volume of injectate (billions of gallons per day), but had a relatively low toxicity potential. The primary injectate was salt water, which, if introduced to a USDW, would only increase the concentration of salts that were already present in most ground water. The injectate also contains hydrocarbons and other contaminants in relatively low concentrations. Furthermore, the taste of brine-contaminated water is so offensive that humans are not able to physically consume enough to harm themselves. On the other hand, the financial incentive of operators could vary widely among disposal, enhanced recovery, and storage wells, and so EPA created a separate category for each on that basis.
  - The only reason that mining wells ended up as the third category was the financial incentive of operators. Class III injectates have large volume, can be very contaminated, and the mined fluids are usually radioactive and full of metals. On the other hand, EPA also recognized that the operator's financial success required that he conserve valuable mining fluids and recover the most product-containing fluid possible.
  - Classes IV and V were created to include everything that didn't fit in the above categories.
- This concept forms the basis for the regulatory oversight of the UIC program. We all should recognize, however, that some Class II fluids are ten times nastier than some Class I injectates, and that the financial incentive is not, in reality, all that it was cracked up to be.

# Basic UIC Principles

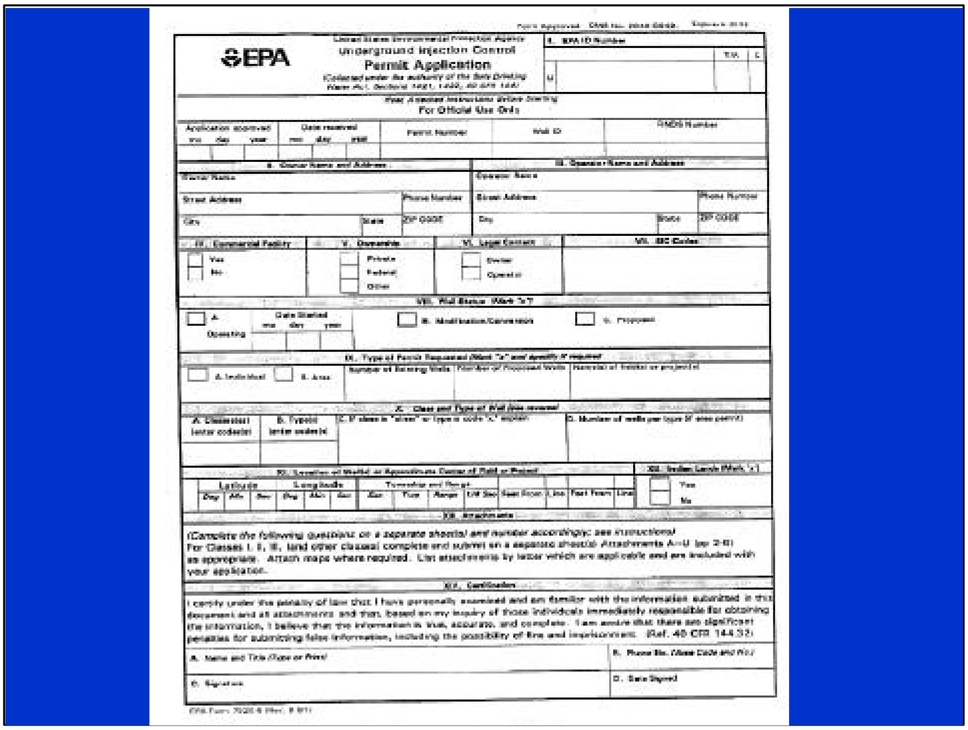
## The Bevill Amendment

- Congressman Bevill introduced amendment to RCRA (1976) to exclude mining wastes
  – 55 FR 22660-61
- Excludes mining of "strategic" minerals and other activities from RCRA hazardous waste regulations

- Congress in 1976 was also developing the Resource Conservation and Recovery Act (RCRA) legislation to regulate wastes. Congress passed Congressman Bevill's amendment to RCRA in order to prevent severe financial impacts to several essential mining industries. Exemptions were enacted for metal-ore processing as well as the coal and oil and gas industries. These mining and extraction processes produce huge volumes of waste products that contain trace concentrations of hazardous constituents. If RCRA considered these wastes to be hazardous, the costs to treat or remove the trace materials from vast quantities of mining-related waste would have been unbelievable.
- The primary effect in the UIC program is to exempt certain Class II wastes from RCRA. In fact, the Bevill amendment exempts ***all*** Class II brines from RCRA, but that wouldn't have had that big an impact on UIC because regulatory prioritization had already created less stringent requirements for wells injecting oil and gas brine.
- More important, however, was a related exemption of production chemicals used in oil and gas operations. There are many solvents, for example, that would be classified as hazardous and the wells injecting them as Class I if they were not used in conjunction with oil and gas production. In order to qualify for the exemption, EPA made the distinction that these chemicals must be used down-hole to qualify.
  - For example, solvents used at a drilling site to clean equipment or to flush a pipeline are listed hazardous wastes and subject to all the provisions of RCRA. If they were to be disposed by injection, it must be into a Class I-H well.
  - On the other hand, if these same solvents were used down-hole as a stimulation treatment to dissolve paraffin deposits in an oil well, when they are produced they are an exempt waste and can be disposed in any Class II well.
- The net effect to us as permit writers and regulators? On any given day, the injectate of a Class II-D well has the potential to contain hazardous concentrations of solvents, acids, and other listed and characteristic RCRA hazardous wastes.




- The first step in the process of acquiring a permit for a UIC facility is, of course, filing an application. In addition to the basic permit application form and various attachments, each project needs to be evaluated to determine if any of the following Federal laws apply, as listed in 40 CFR 144.4:
  - Wild and Scenic Rivers Act;
  - The National Historic Preservation Act of 1966;
  - Endangered Species Act;
  - The Coastal Zone Management Act; and,
  - Fish and Wildlife Coordination Act.
- If any of these acts are applicable to the project, additional interagency coordination will be necessary, and the time frame for permit review and issuance should be expected to be significantly long than usual. These Federal statutes are not listed and included in the application, so make sure you think about them early in the process.


EPA

Underground Injection Control

Permit Application

For Official Use Only

- The UIC Permit Application Form marks the beginning of the permit process (filled in by the operator, of course).
- This same form is used for all injection well classes, so some of the information presented in this course regarding the process and general requirements for permitting will help you when permitting Class I, II, III and V wells. Most of the technical information presented, however, is focused on Class I, Class II and Class III injection wells.
- The basic form is very simple, providing information on the owner and operator (who may not be the same), type of well and facility, status of the well, basic site information (how many wells at the site, etc.), well location information, and whether the well is on Indian lands. This last little box makes a big difference, as the Regions have special agreements with Tribes.
- A certification that carries a tremendous legal weight finishes the form. The owner or operator certifies ***under penalty of law*** that everything submitted in the application is true and accurate. 40 CFR 144.32 lists who is authorized to sign and certify the application. Terms such as “responsible corporate officer,” “general partner,” and “principal executive officer” are used – a person with decision making authority. By doing so, he or she states that the information being submitted has been personally reviewed, and thus personal liability is attached.
- The real work starts after this first page!

# Application Attachments

- Attachments required vary by well type and status (new versus existing)
- Smallest number possible is nine (new Class II well)
- Provide the details needed to determine if the site and well meet Federal criteria

- The application form is actually six pages long, including all the directions. It is one of a series of forms known as the "7520s," which are various reporting forms used in the Federal UIC Program. It is available on EPA Region 5's website at:

  **www.epa.gov/r5water/uic/forms.htm**

- The form alone, without the instruction sheets, is available as part of the 7520s forms at **www.epa.gov/safewater/7520s.html**.
- Primacy States (States that have been delegated authority for the UIC Program and implement it with oversight from EPA) have their own application forms. However, the various elements in the Federal applications must be included in State applications, since State programs have to be at least as stringent as EPA. While additional information may be required by States, the majority of the permitting elements and processes we discuss in this course are applicable to and useful for State UIC program personnel.
- A number of attachments must be prepared and submitted with the first page of the application. Class II wells have the least number of required attachments, and the instruction form tells operators to expect to take about 16 hours to prepare the application. Class I and III wells must submit more information, and the instruction sheet directs operators to expect to spend 200 hours to prepare a Class III application and 255 hours for a Class I well application. You can guess, based on the time, a lot of detail is included.

## So Many Details. . .

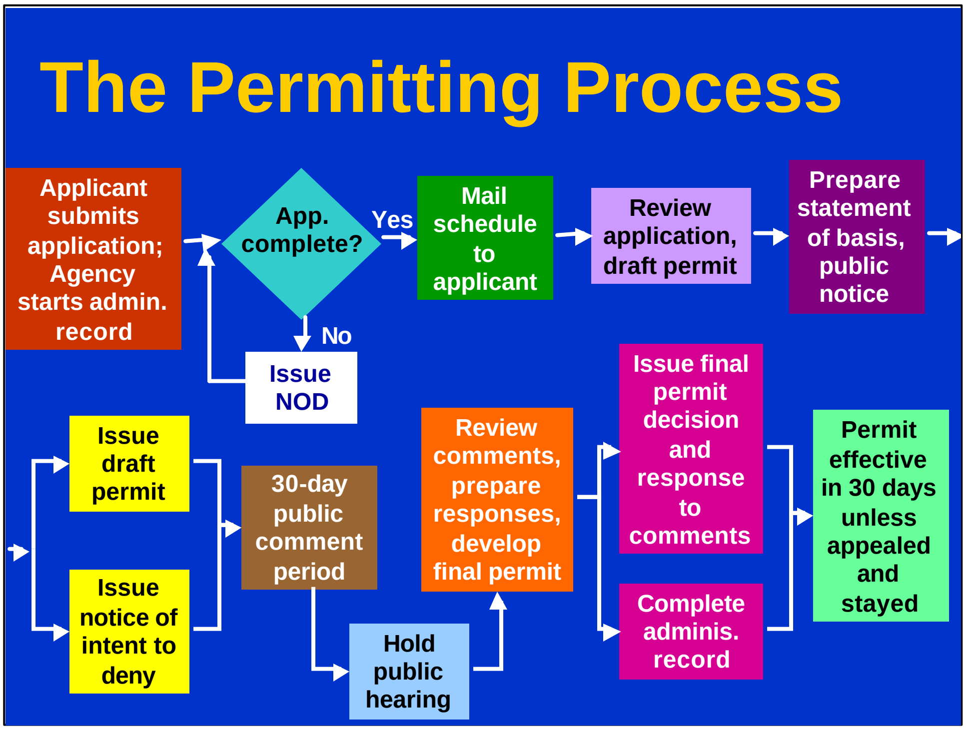
- Details of
  - Site geology
  - Other nearby wells
  - Proposed construction, completion and operation
  - Plans for plugging and abandonment
  - Demonstrating financial ability

- The application contains many details about the owner and operator, the proposed site, and the way the well will be designed, operated, monitored and maintained. All the information sent to and from EPA during the permitting process is public information, unless the owner/operator makes a claim of confidentiality which we will discuss later.
- Some of the information may not be exceptionally exciting as you read it, and might be easy to gloss over. But as a permit reviewer and writer, you need to pay close attention to every detail. Remember that all those details lead back to protection of USDWs. Also, the items listed in the various attachments to the application are ***required*** by the regulations. It is important to identify any deficiencies and list those in writing to the applicant. Failure to identify and deal with deficiencies not only puts the environment at risk, but also may unnecessarily cause the operator to be out of compliance later on.

## Regional Checklists

- Each Region has a permit checklist for at least some well classes
- Provides a good summary and check of required elements in basic form
- Will not answer whether the application is genuinely complete
- Technical review of the details essential

- Most Regions have a checklist for reviewing UIC permit applications. Keep in mind that while the checklist is helpful, many of the details to review are site-specific. Just because information is presented does not mean it is adequate to fully address questions that arise about the proposed facility. An application needs to be complete in all aspects – it must contain all required elements, **and** it must provide the technical details in each element to demonstrate that a permit should and can be issued.
- Use the checklist to see if all the required elements are included, but use good science and logic to make sure the permit application really is complete.
- We are going to discuss each of the attachments that can be required in the permit application for Classes I, II and III injection wells. They are not presented in the order they are listed on the application, but they are all here. If you refer back to this training manual and use the resources available to you in the UIC program personnel around you, you should be able to wade through a fairly complex application and survive!




- The diagram above provides an overview of the permitting process. Prior to the first box on the slide, calls and/or meetings with the applicant may occur. The official responsibilities of the permit reviewer and writer, however, begin upon receipt of the application itself.
- When an application is received, every piece of correspondence, a record of every phone conversation and every e-mail needs to be kept in the administrative record from that point on. The permit writer or reviewer should immediately begin folders for this documentation, since these materials are public record by law. The only exceptions are items for which the applicant makes a claim of confidentiality. If this claim is made, it must be done according to the requirements of 40 CFR 144.5, and EPA ***cannot*** release the confidential information to the public. Usually, each Region will have a policy in place regarding how to handle confidential materials. Be sure you are aware of it and follow it to keep you out of legal hot water!!
- The first step in the permit application review is ensuring that the application is complete. This means it includes all the required elements (the basic application plus all attachments) and they are complete. **"Complete"** is defined in 40 CFR 144.31(d). If the application is incomplete, the reviewer develops and sends a Notice of Deficiency (NOD) and the applicant must respond. Generally, there is a difference between a complete application versus one that is completely adequate technically. All the parts may be there, but additional detail may be required even once the application is "complete."

# How to Swallow the Elephant

- The magic box is **Review application, draft permit**
- DO:
  - Cross-reference materials
  - Take good notes
  - Look at the site and issues holistically
  - Check citations and calculations
  - Keep an excellent record of communications
- DON'T:
  - Review information in a vacuum
  - Make assumptions

- There is one small box on the flow chart (previous page) that has a monstrous elephant crammed into it - and you need to swallow the elephant one bite at a time! New permit reviewers may be a bit overwhelmed with the various pieces of the permit application at first. We will be covering many items that will help you get through the document piece by piece as we move ahead in this course. To start you out, here are a few general pointers:
  - **DO** cross-reference materials to ensure completeness and accuracy.
  - **DO** take good notes (write directly on an extra copy of the application or use Post-It style notes to help you keep track of questions and issues).
  - **DO** look at the site holistically, rather than looking at the well as a point in the ground.
  - **DO** keep a clear record of all communications and steps of the permitting process in the administrative record.
  - **DON'T** review the various attachments and pieces of the application in a vacuum. The types of information submitted are highly interdependent and interrelated. For example, you cannot review the regional and local geology, check that off your list and never go back to it. When you review information about fracture gradient, proposed operating conditions, USDW definition, proposed construction and formation testing, you will need to refer back to the geologic information. When you review a plugging and abandonment plan, you will need to look at construction and financial assurance. So, keep cross-checking and ensure that the application as a whole is complete and accurate.
  - **DON'T** make assumptions. The applicant may or may not have located and used the most pertinent and accurate data. Check citations and references for accuracy.

## Apples and Oranges

- Each well class has different requirements, standards and influences
  - Class I and some Class II (disposal) have highest standards
  - Class III can be unique due to ground water restoration requirements
  - Class V requirements dependent on risk posed by depth of injection and type of injectate
  - Some Class II wells "grandfathered" and you will not have opportunity for review
  - Have realistic expectations for the type of well you are working with

- One last word before we jump into discussions on the various elements of the application itself. The permitting process for each well class is slightly different, based on the regulatory requirements for each well. These requirements grew out of a variety of influences, including perceived risk of the well (based on depth of injection and type of material injected), and lobbying by affected parties. The result is that a permit reviewer cannot necessarily take one application for a UIC well and presume that the same requirements and limitations are either appropriate, relevant or even legal for another well type.
- Remember the limitation placed by SDWA on UIC regulatory development. The program was told not to interfere with the production of oil and natural gas, to take into account the geologic differences that exist across the country, and to consider and not interfere with State UIC program requirements that predated SDWA.
- All Class I, II and III wells are subject to permitting in some form. All Class V motor vehicle waste disposal wells in sensitive ground water areas must be permitted; we'll discuss details later. Requirements for other Class V wells regarding permits are site-specific.
- The bottom line for each UIC well is that it is required to be constructed, operated, maintained and closed in a manner that protects underground sources of drinking water from contamination. This should remain your primary focus throughout the entire permitting process.
- Even "grandfathered" Class II wells (those for which you will not have an opportunity to review a permit and data) are still subject to this standard. Keep your perspective about what is a realistic expectation for a particular well class, based on the regulatory requirements, history of the well type, and, for a primacy State, the approved UIC Program Plan. However, you should definitely remember that regardless of specific programmatic details, all UIC programs are required to use and enforce the non-endangerment of ground water resources.

# Lesson 3
# Existing Permits

# Existing EPA Permits

- All other EPA permits at the facility must be listed
  - NPDES, §404, other CWA
  - RCRA
  - Title V, PSD or other air permits
  - State permits
- Information provided must include program area and permit number
- Gives permit writer ability to check compliance and ensure permitting consistency

- The applicant must include a list of all other EPA permits issued to the facility at which the UIC wells are located. This includes both EPA and State permits under the Clean Water Act, such as NPDES (surface water discharge), RCRA (hazardous waste treatment, storage, and disposal) and Section 404 (dredge and fill including wetlands); CAA (Title V or Prevention of Significant Deterioration); or other permit programs (see 40 CFR 144.31(e)(1) and (e)(6)). When reviewing this information, the permit reviewer should verify this information by contacting the other program areas.
- Additionally, the reviewer should investigate what the compliance rate of the owner/operator has been under these existing permits. This can help determine whether special terms and conditions may be necessary if the owner/operator is historically a significant noncomplier in other programs. At a minimum, it will alert you to closely evaluate details, and ask questions, if the owner/operator's reputation with the Agency is poor. If the facility has had major environmental problems in the past, you will be aware of the history and status. Such issues are likely to arise at any public forum at which the permit is discussed, and you will be better prepared.
- Finally, it is important for the Agency to issue permits that are compatible and consistent with one another. For instance, if the facility has a RCRA permit that forbids the owner/operator from bringing a certain substance on site for treatment or storage (such as PCBs), the UIC permit should not authorize disposal of that substance in a Class I UIC well.

## RCRA and UIC Overlap

- RCRA and UIC can both affect a UIC well
- RCRA regulates above ground hazardous waste units
  - Both may regulate filtration system and other treatment that may affect injectate quality
- Land disposal restrictions apply to Class IH wells
- Certain mining and other wastes exempt from RCRA under Bevill amendment
- Coordinate closely with RCRA staff on all well classes to ensure all regulations applied appropriately

- The hazardous waste program under RCRA and the UIC program under SDWA have a variety of overlaps.
- If hazardous waste generation, storage, treatment or disposal occurs at a site, RCRA applies in some form. Generally, the RCRA program's oversight of the facility will end at the wellhead. Even Class I UIC wells used for disposal of hazardous wastes are permitted under the UIC program, not RCRA (they receive a permit-by-rule under RCRA if they have a UIC permit).
- Some portions of the facility, such as the filtration system, may be regulated by both RCRA and UIC. Since filtration may be "treatment" and it is above ground, RCRA has authority, However, the filtration system directly affects the quality of the injectate, and the UIC program may also regulate it.
- Under the Hazardous and Solid Waste Amendments (HSWA) to RCRA in 1986, land disposal of hazardous waste is prohibited unless it is treated to meet specified standards (called the land disposal restrictions or LDRs) or it is disposed of in a land disposal unit that has an approved ***"no-migration"*** petition. All Class I hazardous waste disposal wells have to receive an approved no-migration petition, above and beyond the permit, to dispose of hazardous waste that does not meet the treatment standards.
- Be aware, also, that certain mining wastes and other wastes are specifically exempt from RCRA regulation under the Bevill amendment and other EPA interpretations, regulations and policy pursuant to the Bevill exclusions. You should coordinate closely with RCRA staff on these issues that may affect a variety of UIC wells.
- Waste generators are required to determine whether the wastes they generate meet the definition of hazardous waste. Again, coordination with Regional RCRA personnel will make the review and interpretation of this information much simpler than trying to make the determinations on your own.

# Other Federal Statutes Affecting UIC

- Toxic Substances Control Act - PCB issues
- Clean Water Act - storm water, antidegradation
- Emergency Planning and Community Right-to-Know Act - Toxic Release Inventory
- Federal Land Policy and Management Act - mining site requirements on Federal lands

- The Toxic Substances Control Act (TSCA) sets standards for disposing of polychlorinated biphenyls (PCBs) and limits land disposal of PCB wastes.
- The Clean Water Act (CWA) may affect the UIC program in a variety of ways. Guidance issued by the Office of Wastewater Management (OWM) promotes use of storm water drainage wells (a type of UIC well), and antidegradation requirements may encourage regulated entities to seek other methods of discharging waste waters, including injection. State CWA-authorized programs may issue subsurface discharge permits that do not consider or may not be consistent with UIC regulatory requirements.
- The Toxics Release Inventory (TRI) is an annual report of toxic chemicals released into the environment by businesses throughout the country, required under Section 313 of the Emergency Planning and Community Right-to-Know Act (EPCRA). Underground injection of toxics is considered a release and must be reported under the TRI.
- Bureau of Land Management (BLM) implements the Federal Land Policy and Management Act of 1976. This statute regulates mining sites on public lands. These sites may have UIC wells.
- In addition, UIC regulations require that EPA consider numerous Federal laws when issuing UIC permits, including Section 7 of the Wild and Scenic Rivers Act, Section 106 of the National Historic Preservation Act , Section 7 of the Endangered Species Act, Section 307(c) the Coastal Zone Management Act, and the Fish and Wildlife Coordination Act. These laws are considered to insure that injection operations do not adversely affect other important nearby resources and sensitive areas, as discussed on page 2-1.

# Lesson 4
# Description of Business

# Brief Summary

- Attachment includes facility tracking information
- The owner/operator briefly describes the business as supplement to page 1 of the application form
  - What's happening at the site
  - Relationship to well operations

- The owner/operator filing the application is required to submit Attachment U, a description of the business. This does not have to be a highly technical discussion, but merely a brief summary of the nature of the business being conducted.
- It should include a brief summary of the primary business aspects of the site and how the injection wells fit into that. It need only be a paragraph or two.
- This information provides a textual supplement to the basic business information provided on the first page of the application. For instance, page 1 of the application requires the applicant to list up to four Standard Industrial Classification (SIC) codes that best reflect the principal products or services provided by the facility (40 CFR 144.31(e)(3)). The description in Attachment U will state in text form what the facility does. For instance, a SIC code of 3312 may be provided on page 1 of the application submitted by the operator of a hot-rolled steel manufacturing facility. The description would state that the facility manufacturers hot-rolled steel and steel products. The operator would probably state that the application was being submitted for disposal of spent pickle liquor (a hazardous waste) in a Class I hazardous injection well.

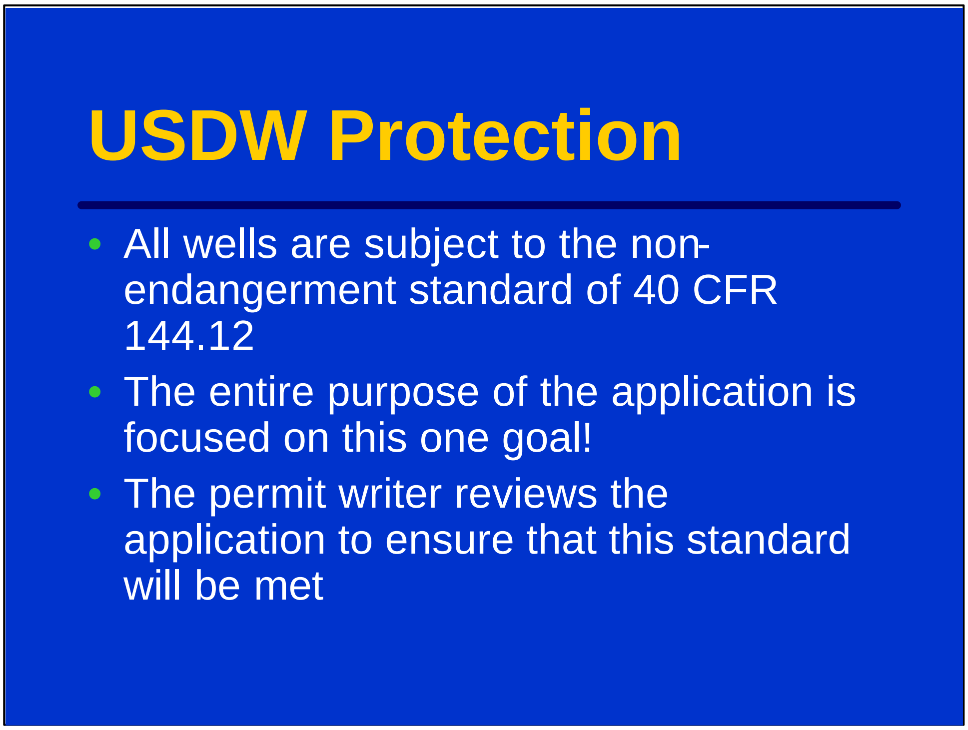
## Using the Information

- Information from the attachment is useful for the fact sheet or statement of basis and for public information

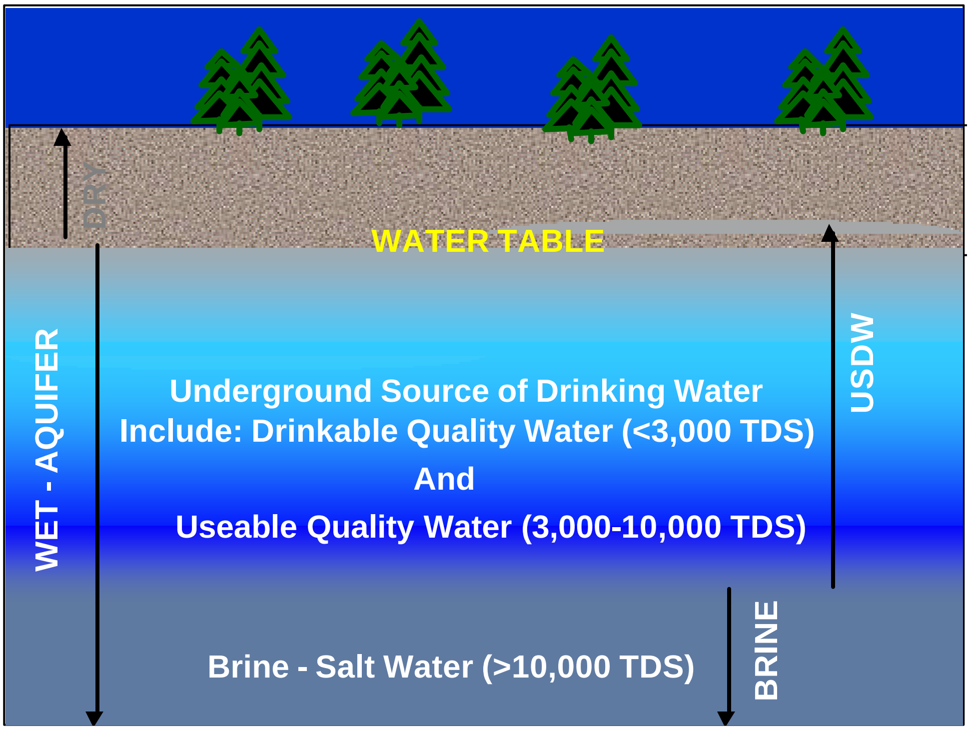
- Checking the basic information in this attachment is straightforward.
- The information can be useful when preparing a fact sheet or statement of basis for the facility, and for general public information. We will talk more about fact sheets and statements of basis later in this course, under the Public Participation section.

# Lesson 5
# USDW Identification and Protection

- The primary mission of the UIC program is protection of underground sources of drinking water (USDWs). In 40 CFR 144.52(b)(1), the Director has the authority to impose permit conditions on a case-by-case basis as necessary to protect USDWs. It is extremely important, then, to have accurate information regarding the location and characteristics of USDWs at an injection well location.
- , “An aquifer or its portion:
  - o (a)(1) Which supplies any public water system; or
  - o (2) Which contains a sufficient quantity of ground water to supply a public water system; and
    - – (i) Currently supplies drinking water for human consumption; or
    - – (ii) Contains fewer than 10,000 mg/l total dissolved solids; and
  - o (b) Which is not an exempted aquifer.”
- This means the permit must consider aquifers (and portions of aquifers) that do not currently supply water to a public water supply but are ***capable*** of producing that quantity of water.




- All UIC wells are prohibited from endangering USDWs (40 CFR 144.12). The prohibition on endangerment includes not only every day operations, but construction, conversion, well maintenance and plugging and abandonment. The entire purpose of EPA's requiring permits, your reviewing the application and writing conditions into the permit is focused on this one goal. The non-endangerment standard applies from the time the well begins construction until the end of time! As stated in the non-endangerment standard of 144.12:
  - **"The applicant for a permit shall have the burden of showing that the requirements of this paragraph are met."**
- So, the permit application must clearly demonstrate that USDWs will be protected and will not be contaminated throughout well construction through the operational life of the well, and even during and after plugging and abandonment of the well.
- If sufficient evidence is not supplied to show USDWs will be adequately protected, special conditions may be included in the permit to assure protection, or the permit may be deemed incomplete or, ultimately, may be denied.




- Attachment D of the permit application requires that maps and cross sections of USDWs present at the site be included in the permit application for Class I and Class III wells. This information is not required for Class II well applications.
- For Class I wells, both vertical and lateral limits of all USDWs in the area of review must be identified, while Class III well applications must include maps and cross-sections showing only the vertical extent of USDWs. [Note: "Area of Review" is defined in the regulations and will be discussed in detail later in the course. For now, just be aware that it is a radius around the well where injection pressures in the injection zone may cause fluids to migrate upward into a USDW.]
- The cross-sections and maps must show the position of all USDWs relative to the formations receiving the injected fluid, and the direction of water movement (if known) for every USDW that may be affected by the proposed injection. Generally, that means all USDWs present.

## Class II USDW Identification Requirements

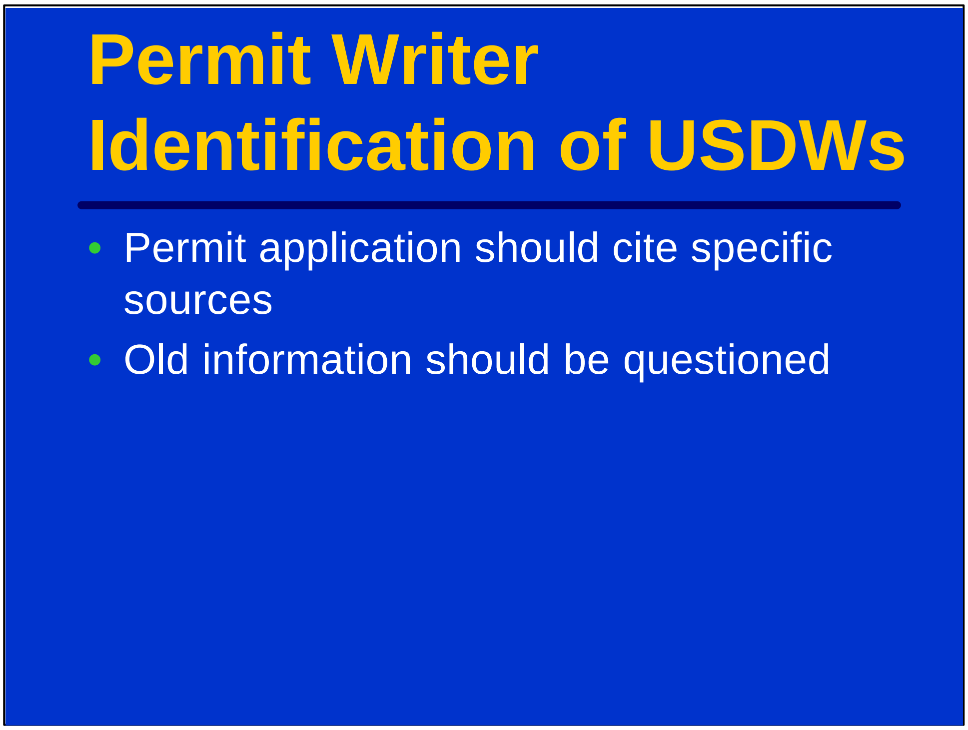
- Maps and cross-sections of USDWs not required
- Must include list of all USDWs that may be affected by injection

- For Class II injection well applications, Attachment E is applicable. This attachment requires a listing of all USDWs that may be affected by the injection operation. Note that this may require evaluation of formations extending some distance from the site, especially in areas where pressures may be affected by injection activities for a significant lateral area from the injection well.
- The list must include the geologic name and the depth to the base of all USDWs that may be affected. Again, unless some extraordinary circumstance arises, it is likely that any USDW near the facility is going to potentially be affected by injection, especially if one considers a worst case scenario of a release into USDWs from a major mechanical integrity failure in a well.

# Permit Writer Identification of USDWS

- State geological survey maps
- Drinking water program and source water program staff
- DRASTIC maps, ground water resource maps, and other hydrogeological maps
- Local health departments

- While the permit applicant is responsible for identifying all USDWs present that may be affected by injection, how does the permit writer know if the information submitted is accurate and complete? There are many sources the permit writer can use to verify the information submitted by the applicant.
- First, there may be other UIC permit applications and permits in the same area. Be sure to find out if there are other nearby wells, including other classes of wells besides the well class that is the subject of the application, that may provide valuable information.
- Drinking water and source water protection program personnel often have information regarding locations and geologic descriptions of public water supply wells. Source water protection program personnel usually have a wide variety of information about water supply capabilities of various aquifers.
- The State geologic survey often can provide a wealth of information regarding water well logs and drilling records, various formation maps, and basic geologic information regarding fresh water production in the area. DRASTIC maps, ground water resource maps, and other hydrogeologic maps, generally available from a geologic survey, can also provide valuable information.
- Local health departments may also have records of private water wells, if a public water supply well is not located nearby. Remember, if the aquifer or a portion of it is capable of supplying a public water supply, it's a USDW.




- The permit applicant does bear the burden of proof in the application, so the applicant should provide detailed information regarding USDWs. Citations should be provided that will allow you to review information the applicant used and check it to see if it is accurate and complete.
- Sometimes a renewal application will not include the most recent data on USDWs, or other geologic data for that matter. If only older citations are provided, check to see whether more recent information is available.

# USDW Review Summary

- Check cited information sources
- Coordinate with other agencies and departments with ground water information
- Make sure of the >10,000 TDS determination
- Check claims of no USDW being present
- Specifically identify USDWs in the permit
- Document in administrative record EPA's decisions on what is or is not a USDW

- In summary, your review of USDW information should evaluate all the data provided, and involve others outside the UIC Program.
- Check the sources of citations in the application. By coordinating with other agencies or departments that collect and retain ground water information, you can save yourself a good deal of legwork.
- If the applicant claims that a USDW is not present, it is very important to review maps and talk with geologic survey, source water or other knowledgeable personnel. An applicant for a UIC well may be motivated to state a USDW does not exist because permit conditions may be less stringent in the absence of a USDW (at the Director's discretion). If the Agency agrees with this determination that a USDW is not present, it sets a precedent for other actions taken in the vicinity of the injection well regarding protection of ground water. It is not unusual for private wells to exist within the search radius. The productivity of private wells needs to be compared to the drinking water program standards and definitions for the smallest public drinking water systems (transient, non-community public water supplies). The necessary production rate can be as low as 1 gpm. If a private well is capable of supplying the quantity of water the drinking water program would regulate if it were a public water supply, the formation is a USDW.
- Once you have come to a determination in your review as to which formations comprise USDWs within the area of the UIC well's influence, make sure two things occur. Ensure that all USDWs, including the determination of the lowermost USDW, are identified in the UIC permit (either in the body of the permit or an attachment). Also, make sure your determinations are noted and placed in the administrative record of the permit.

# Estimating TDS Using Electric Logs

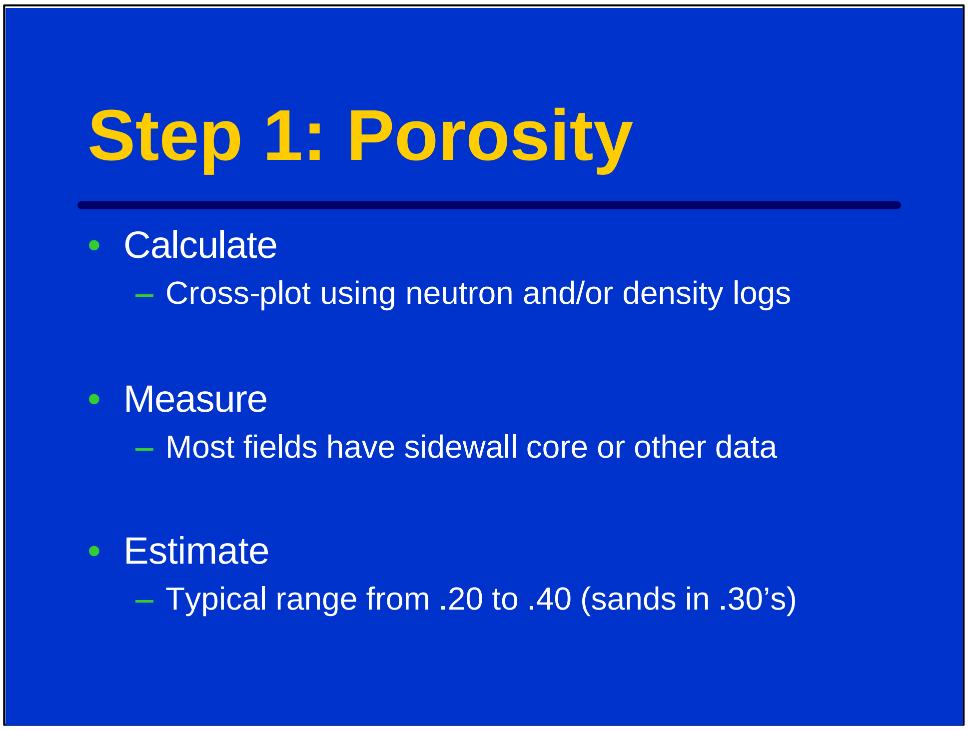
- Archie (1942) and Humble (1953):

$$R_w = \frac{F^m R_t}{0.62}$$ where

- Rw = resistivity of formation water
- Rt = resistivity of formation
- F = porosity
- m = cementation factor

- There are many occasions during permitting or enforcement when it becomes necessary to know the total dissolved solids (TDS) content of a particular aquifer or to identify the true depth to the base of the lowermost USDW, i.e., where the saline content is 10,000 mg/l TDS. Most literature references are regional in scope, rather than specific. State publications or water-well data, if available, are usually oriented to drinking water aquifers of low TDS content. In a perfect world, a permit writer should be able to get water samples just by wishing on a magic lamp, but in most cases, what you will have in front of you is an electric log.
- In 1942, G.E. Archie defined an empirical relationship between the resistivity of the formation fluids, the porosity of the formation, and the TDS concentration of the formation water. Humble (1953) simplified Archie's relationship for porous formations as:

  **$R_w$ = porosity (to the power of m) times Rt, divided by 0.62**, where:
- "$R_w$" is the **resistivity** of the formation water;
- "m" is Archie's "**cementation factor ;**" and
- "$R_t$" is the resistivity of the **formation**.
- $R_t$ can be picked from a wireline log using a deep-focus curve in a thick (>5feet), water-saturated bed. "m" is estimated using empirical values for differing degrees of cementation and burial, and porosity can be calculated, estimated, or measured. Using the solution for $R_w$, we can estimate TDS concentration using standard tables. This method is variously called the "Archie method" or the "resistivity method."



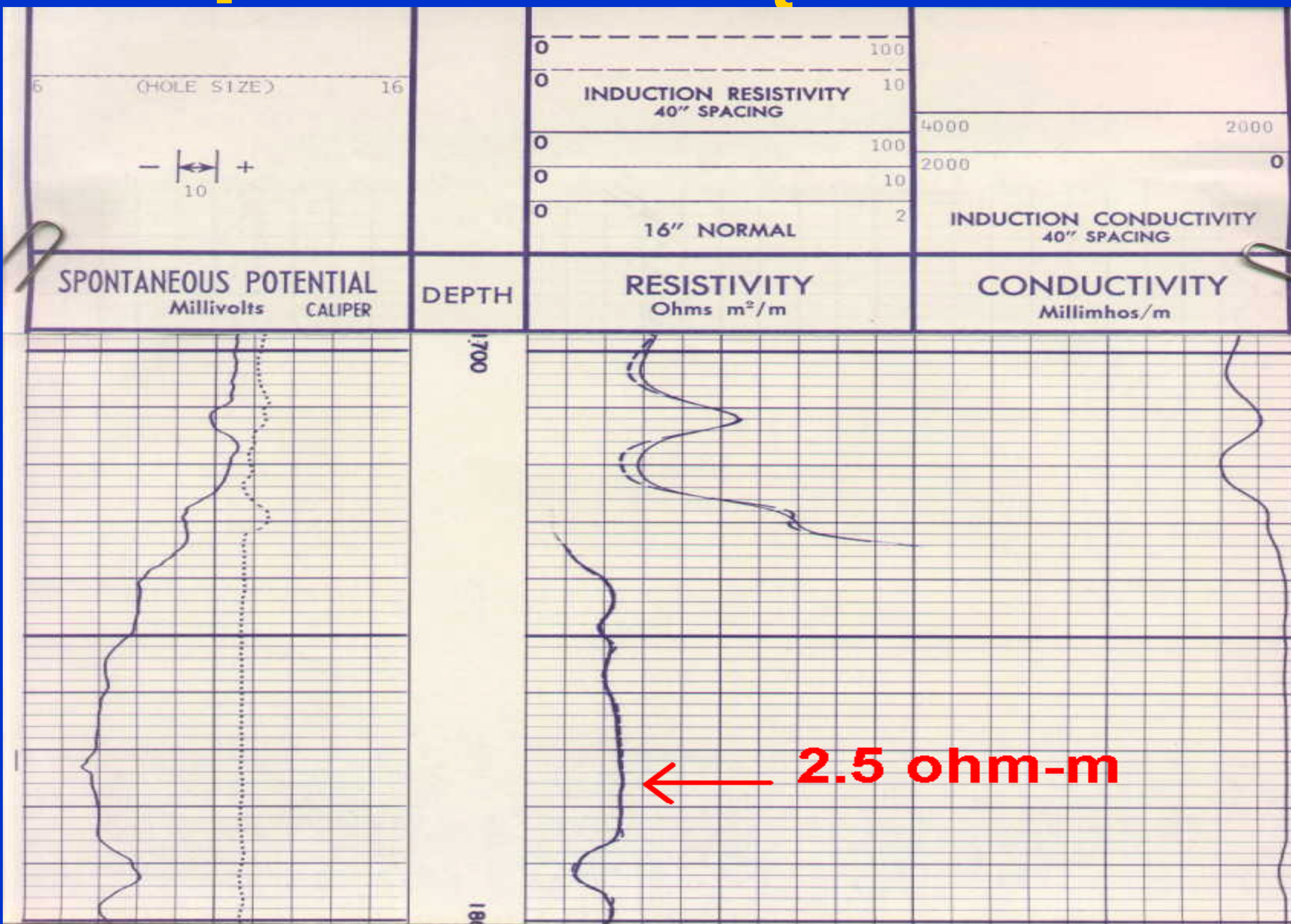

- Step one of the resistivity method involves the determining formation porosity. There are three methods of determining porosity for this analysis.
  - **Calculate:** If sonic, density, or neutron logs are available for the well, one can cross-plot porosity using two logs for known lithology or three logs for unknown lithology. See any log interpretation manual for details.
  - **Measure**: The subject well or other wells in the field may have sidewall core data.
  - **Estimate**: Because we are almost always interested in water-saturated aquifers, porosity probably ranges from .20 to .40, with most sandy formations likely in the .30's. Because the possible range is relatively small, estimates of porosity are usually satisfactory.
- For our example well, the porosity of the zone of interest was measured at 32 percent.

## Step 2: Cementation Factor

- Calculate
  - $R_t$ versus F log-log plot with depth
- Estimate (Guyod, 1944)
  - Highly cemented (limestone, quartzite): 2.0 – 2.2
  - Moderately cemented (consolidated sands): 1.8 – 2.0
  - Poorly cemented (friable, crumbly sands): 1.4 – 1.7
  - Unconsolidated sands: 1.3

- Archie described a “cementation factor” which relates to the degree of cementation and burial. He intended that this factor be calculated: if several values of $R_t$ versus sonic or neutron porosity are plotted on a log-log graph with increasing depth, then “m” is the slope of a best-fit line. Archie considered that most deep cemented sandstones had a value of 2.15 for “m.”
- Guyod (1944) found, however, that “m” varies predictably with lithology. He proposed the following values of “m:”
  - Highly cemented (limestone, dolomite, quartzite): 2.0 – 2.2
  - Moderately cemented (consolidated sands): 1.8 – 2.0
  - Poorly cemented (friable, crumbly sands): 1.4 – 1.7
  - Unconsolidated sands: 1.3
- Most USDWs are relatively shallow, and typically exhibit “m” values of 1.4 to 1.8. Our example zone is located from 1725 to 1820 feet depth from surface, and is located in south Texas. A typical range of “m” for Gulf Coast sands would be about 1.6.

# Step 3: Pick $R_t$ and Solve




- This analysis requires a resistivity, induction, or Laterlog-type well log, although you can even use a value from a pre-1940 "electric log." Choose a log value for formation resistivity in a clean, permeable, thick (>5 feet) bed. If you are using a resistivity log, use a "deep-focused" curve. Always watch the scale, and make sure you have the decimal in the right place. In this case, the value is 2.5 ohm-meters.

## Solve for $R_w$

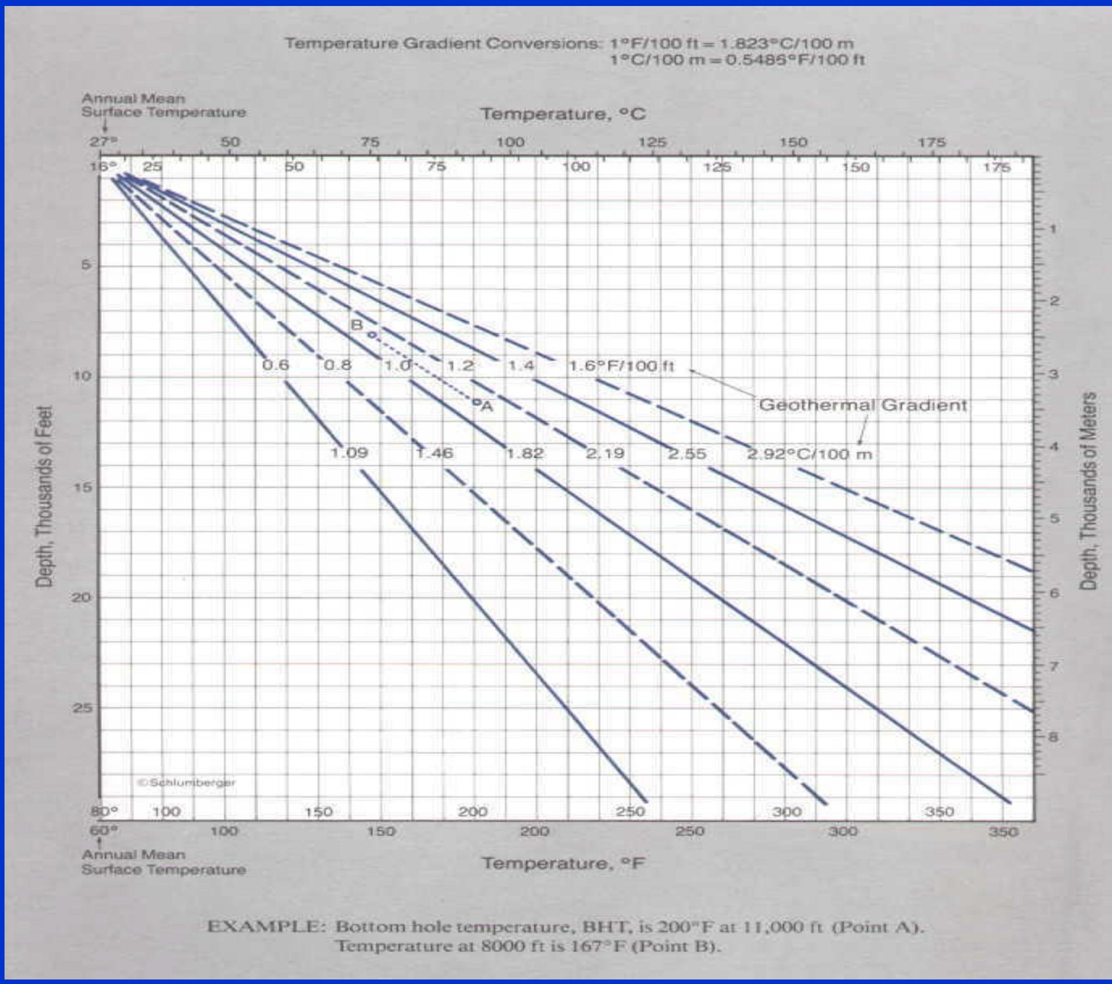
$$R_w = \frac{F^m R_t}{0.62} \quad \text{or}$$

$$R_w = \frac{(.32)^{1.6}\,(2.5)}{.62} = .65$$

- $R_w$ is the resistivity of the uninvaded formation water. The solution for our example would be .32 raised to the 1.6 power, times $R_t$ (2.5), divided by .62. Therefore, in our example, $R_w$ would equal .65.

# Step 4:

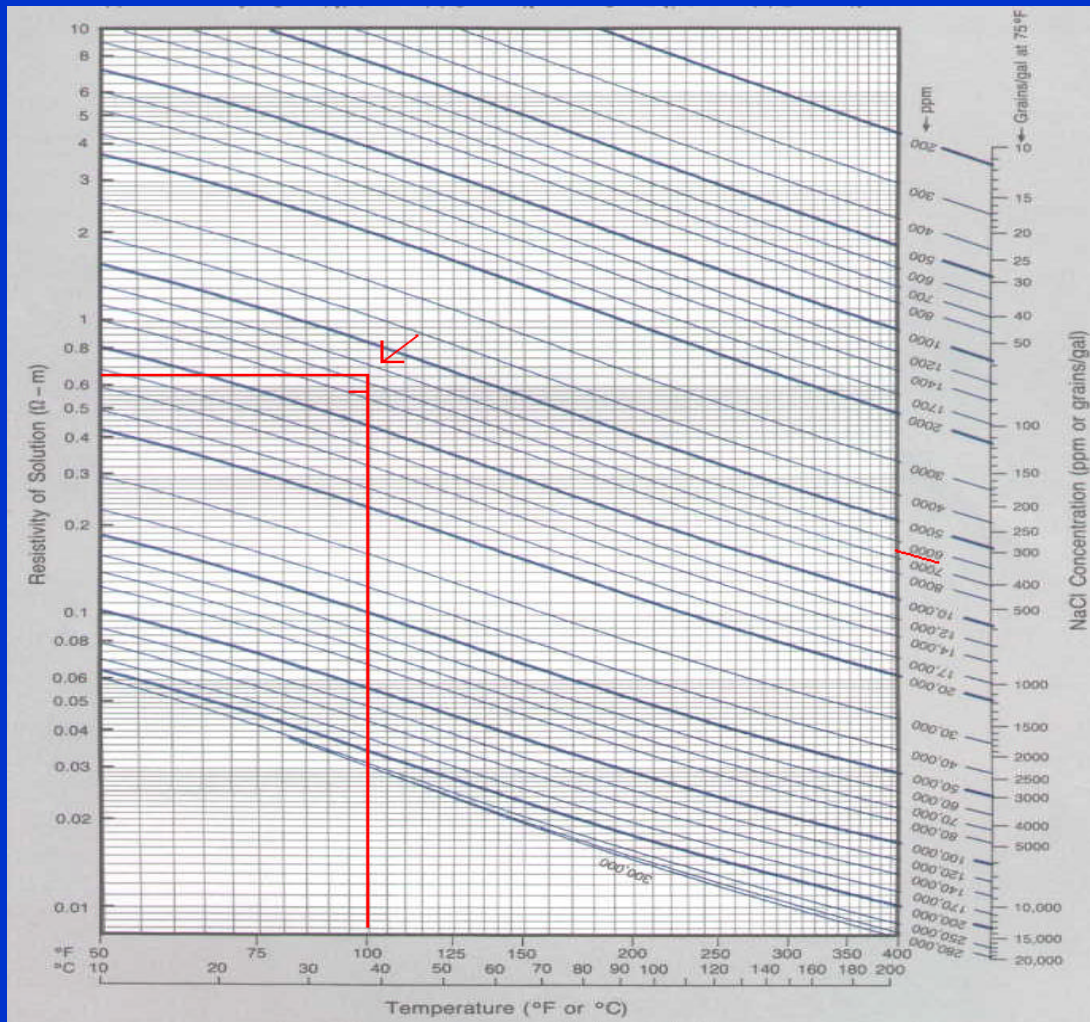
## Estimate formation temperature




- Most log headers will list the surface and bottom-hole temperatures. You must convert bottom-hole temperature to the temperature in the zone of interest.
- This is a typical graph of geothermal gradients. These graphs use mean annual surface temperature and a bottom-hole temperature as the basis. For deeper aquifers (>1,000 feet), use this handout or your own graph to calculate the temperature at the depth of the selected formation. For aquifer depths less than 1,000 feet, use a value between 75 and 90 degrees, depending on average surface temperature and depth.
- Our example log header measured bottom hole temperature as 107 degrees F at 2850 feet. The corrected temperature in our example zone at 1780 feet would be about 99 degrees.

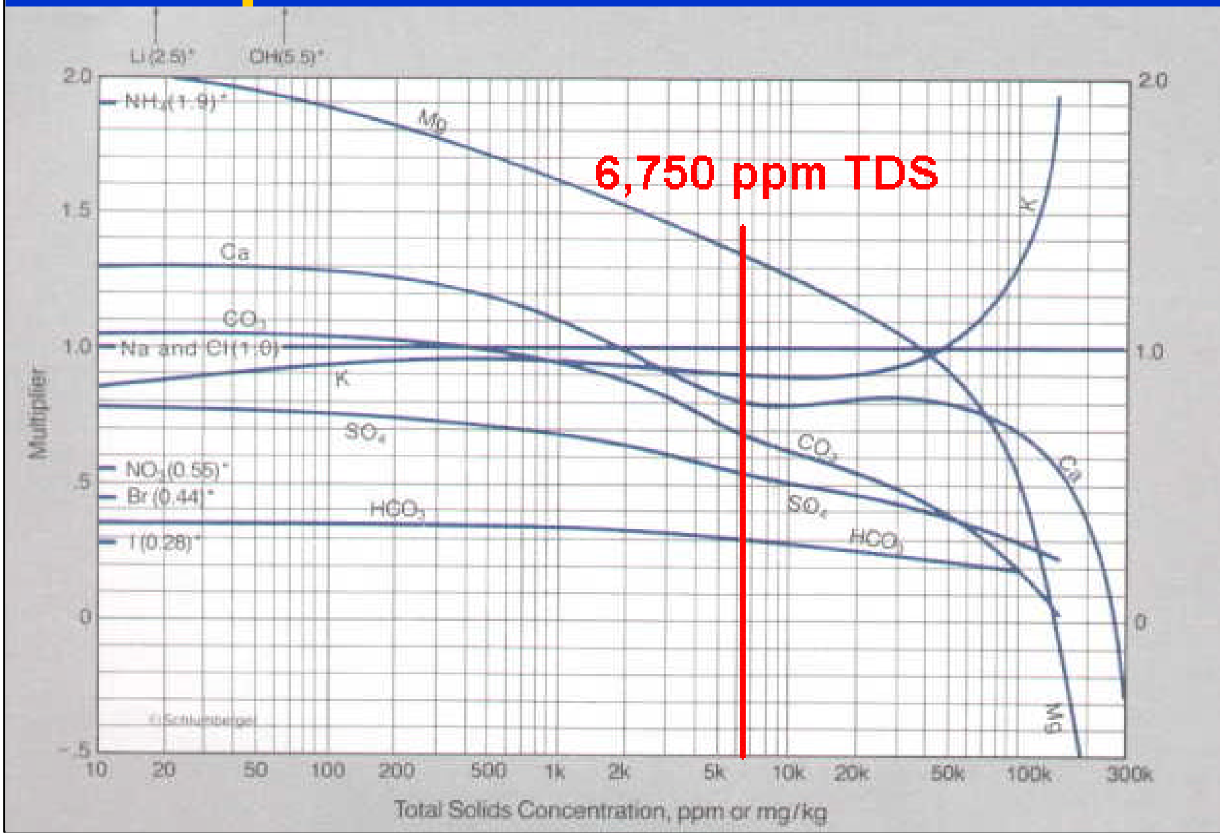
# Step 5:

## Estimate TDS as NaCl



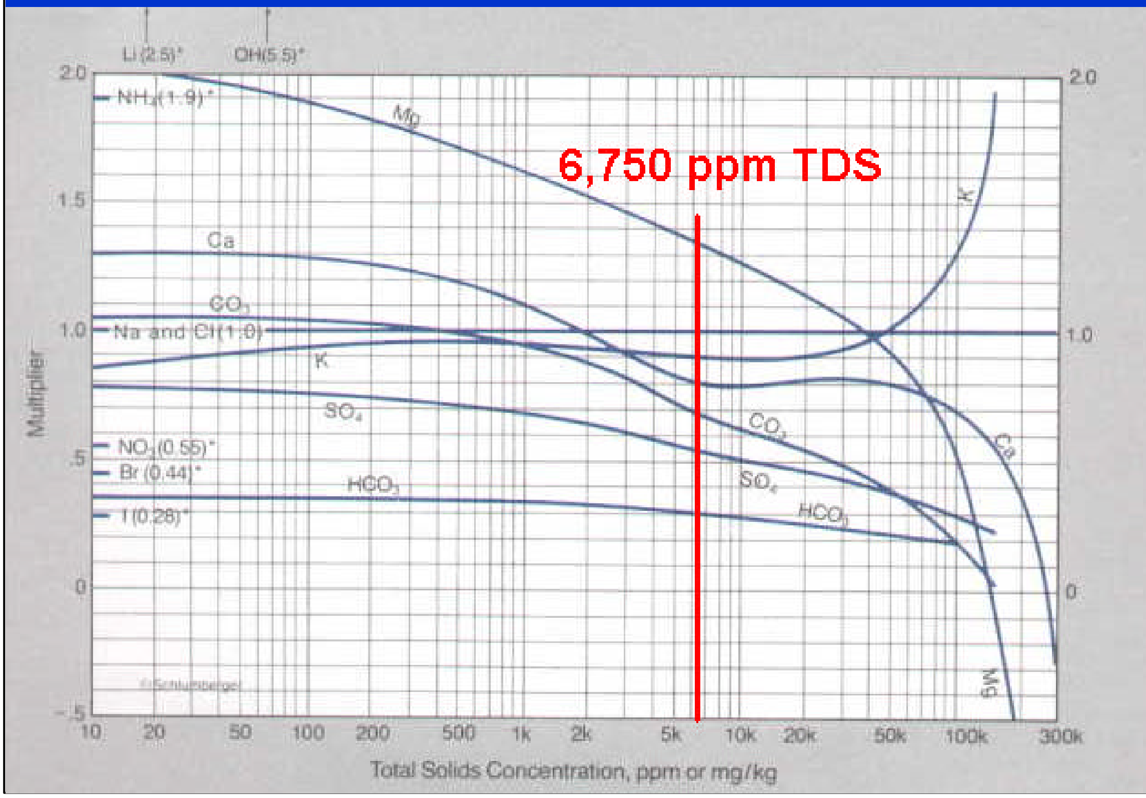

- Use this graph to convert $R_w$ to TDS.
  - First, find Rw on the vertical axis (left side) of the graph. Note that the vertical axis features log-$R_w$. In our case, the $R_w$ value was .65.
  - Then find the formation temperature of 99 degrees on the bottom of the graph. Use the upper right corner of a sheet of paper, and align the right edge with temperature and the top edge with $R_w$. The "point" of the edge indicates the TDS of our example: it falls vertically between two blue iso-concentration lines.
  - Read down to the right to find the TDS of the nearest iso-concentration line. In our case, the tip lies about 3/4 of the vertical distance between the 6000 and 7000 TDS iso-concentration lines, indicating about 6750 ppm TDS.
- Note that this value is for sodium chloride solutions.

# Step 6: Convert Solutes




- The $R_w$/TDS conversion graph of the previous slide yielded an answer as TDS of NaCl. While this assumption is very accurate for deeper, more saline aquifers, it yields TDS values that are inappropriate for USDWs, which usually feature ions such as calcium, magnesium, bicarbonate, and sulfate. The net effect is that $R_t$ will read lower in a sodium-chloride zone than it would in a calcium-bicarbonate zone. In other words, our analysis thus far has stated the results as sodium chloride, which **overstates** the actual TDS if they are typical USDW constituents. In other words, our answer as NaCl represents the worst case – 6,750 ppm TDS is the most saline the aquifer could be.
- In theory, most aquifers that contain less than 4,000 TDS probably feature calcium, bicarbonate, and sulfate as the dominant ions, rather than sodium chloride. Aquifers containing between 4,000 and 10,000 TDS probably feature a combination, so, for our example, we should consider an answer somewhere in between.
- Step 6 uses Sinclair's method to convert the results from NaCl to USDW solutes. For each ion other than sodium and chloride that is present in the aquifer, Sinclair assigns a multiplier to adjust the ion concentration. In simple terms, we already know what the resistivity of the formation water is. The multiplier will adjust the amount of each ion to reflect the true concentration.
- Enter the chart at the appropriate total-solids concentration of the solution, in this case, 6,750 ppm as sodium chloride. Notice that if the solution were 100 percent NaCl, the multiplier would be "1," that is, the TDS is not adjusted. If, for example, the solution were 100 percent bicarbonate, at 6,750 TDS the multiplier would be .3. To adjust for the presence of 100 percent bicarbonate, we would multiply 6,750 by .3, which equals 2,025. This result says that 2,025 ppm of bicarbonate in solution would give the same resistivity reading as 6,750 ppm of sodium chloride.

# TDS as USDW




- As stated earlier, aquifers that contain less than 4,000 TDS probably feature calcium, bicarbonate, and sulfate as the dominant ions, rather than sodium chloride. Aquifers containing between 4,000 and 10,000 TDS probably feature a combination; so for our 6,750 TDS aquifer we probably should consider a composition somewhere in between.
- Let's consider the best case: assume that the zone contains water characteristic of USDWs with calcium, bicarbonate, and sulfate. Fifty percent of the ions would be calcium, 25 percent would be bicarbonate, and 25 percent would be sulfate. The multipliers at 6,750 are calcium .8, bicarbonate.3, and sulfate .53. The analysis looks like this:

**(3375 x .8) + (1687.5 x .3) + (1687.5 x .53) = 4,100 ppm TDS**

- This would be the true salinity if the ions were representative of fresh water, that is, only calcium, bicarbonate, and sulfate.
- We said earlier that USDWs over 4,000 TDS probably feature a combination of ions. Let's assume a typical brackish composition: 50 percent of the solutes are sodium chloride, and the balance is calcium sulfate. That analysis would be:

**(3375 x 1) (the multiplier for sodium and chloride) + (1687.5 x .8) + (1687.5 x .53) = 5,619 ppm TDS**

- What have we learned about our example zone? The zone features water that contains, as sodium chloride, 6,750 ppm TDS. The zone could conceivably contain as little as 4,100, but probably contains about 5,600.

# SP Method

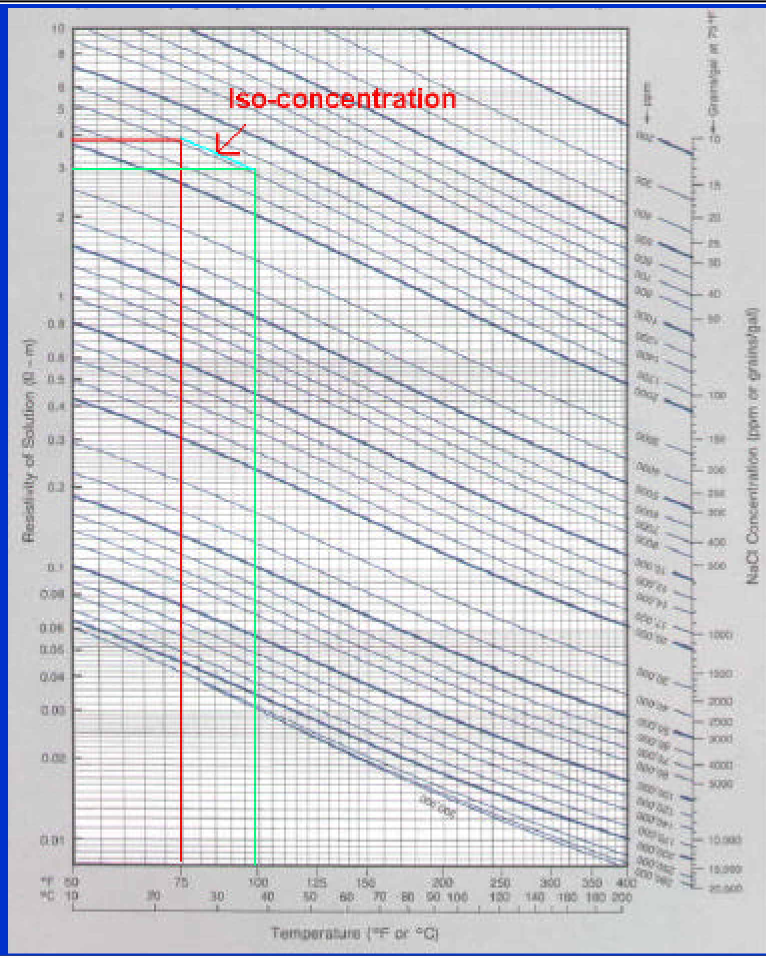
- Utilizes SP log and mud conductivity
- Use only when:
  - Mud is fresh water, and
  - Beds are thick (> 5 feet)
- Will not work in carbonates

- So far we have been considering only one of the two methods for calculating TDS from a well log, namely the Archie or resistivity method. The other method is called the "SP method." When fresh water in the borehole is in contact with more-saline formation fluids, a small electrical current is generated. Measurement of the voltage change with increasing permeability generates a spontaneous potential log.
- The resistivity method holds up in almost every situation, but there is one situation where the SP method is better: when fresh-water mud is used for drilling and logging. Almost all oil wells will use saline mud to prevent formation damage to deeper zones. In some cases, however, operators will use city water for mud to drill the surface-casing hole and log the shallow section.
- The only problem with the SP method is that it is not valid in thin beds (less than 5 feet) or carbonates.

# Step 1:

$R_{mf}$

@ temp




- First we need to establish the resistivity of the mud filtrate, or $R_{mf}$. Mud filtrate resistivity is usually listed on the log header, usually as $R_{mf}$ @ surface temperature. We must convert resistivity at surface or bottom-hole temperature to resistivity at **formation** temperature.
- For this we use the resistivity/TDS chart. Our log header gave us $R_{mf}$ as 3.81 at 75 degrees F, and we calculated the formation temperature as 99 degrees F.
- Using the upper-right corner of the paper, index the value of 3.81 and 75 degrees. The intersection is the equivalent TDS concentration, as before. Slide down the iso-concentration line until you intersect the 99 degrees mark on the bottom scale. Read left for the $R_{mf}$ value at 99 degrees, in this case 3.0 ohm-m.
- $R_{mf}$ was measured as 3.81 at surface temperature. We found that if measured at formation temperature, $R_w$ would measure 3.0.

## Step 2: Determine $R_{mfeq}$

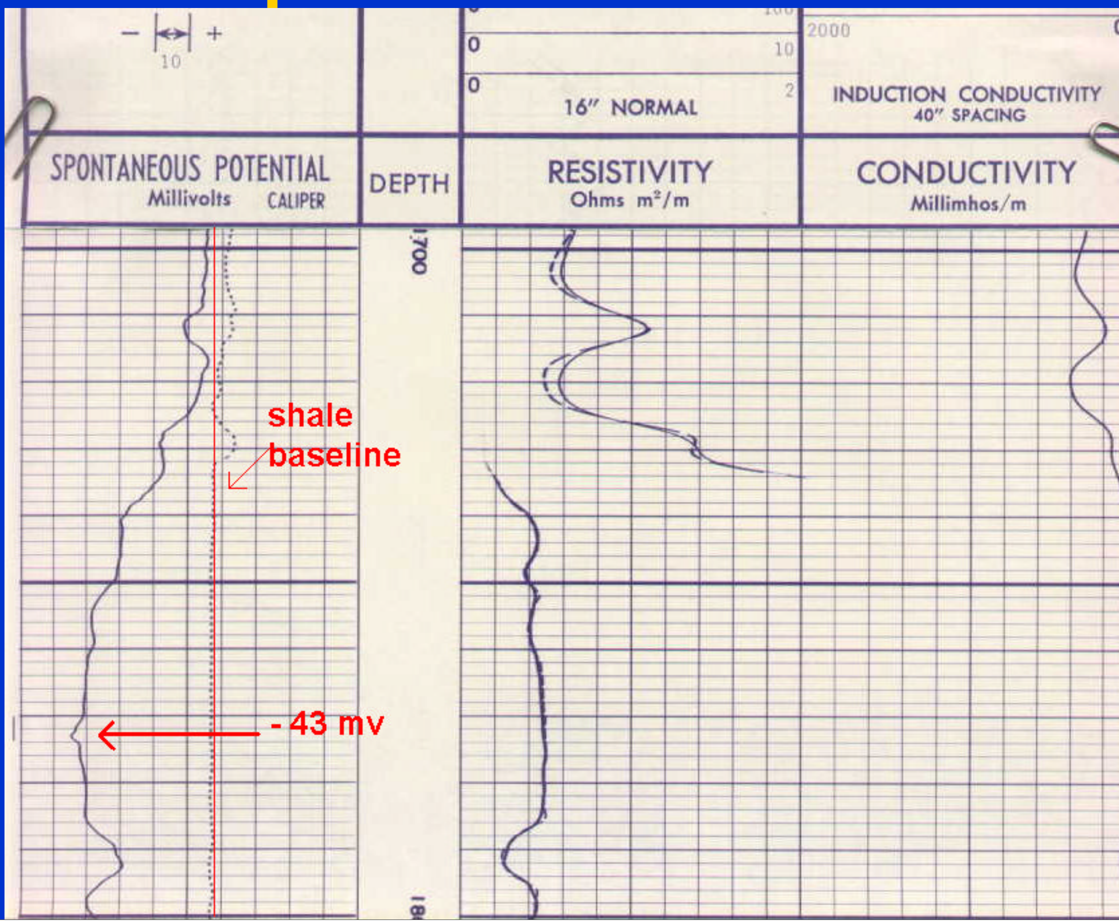
$$R_{mfeq} = 0.85\ R_{mf}$$

or

$$R_{mfeq} = .85 \times 3.0 = 2.6$$

- For $R_{mf}$ greater than 0.1 ohm-meter, this relationship is true. Since $R_{mf}$ is almost always greater than 0.1 ohm-meter for shallow SP logs, this simple relationship provides a shortcut. For our example well, $R_{mf}$ at reservoir temperature equals 3.0. Substituting in the equation, we can solve that $R_{mfeq}$ equals 2.6.

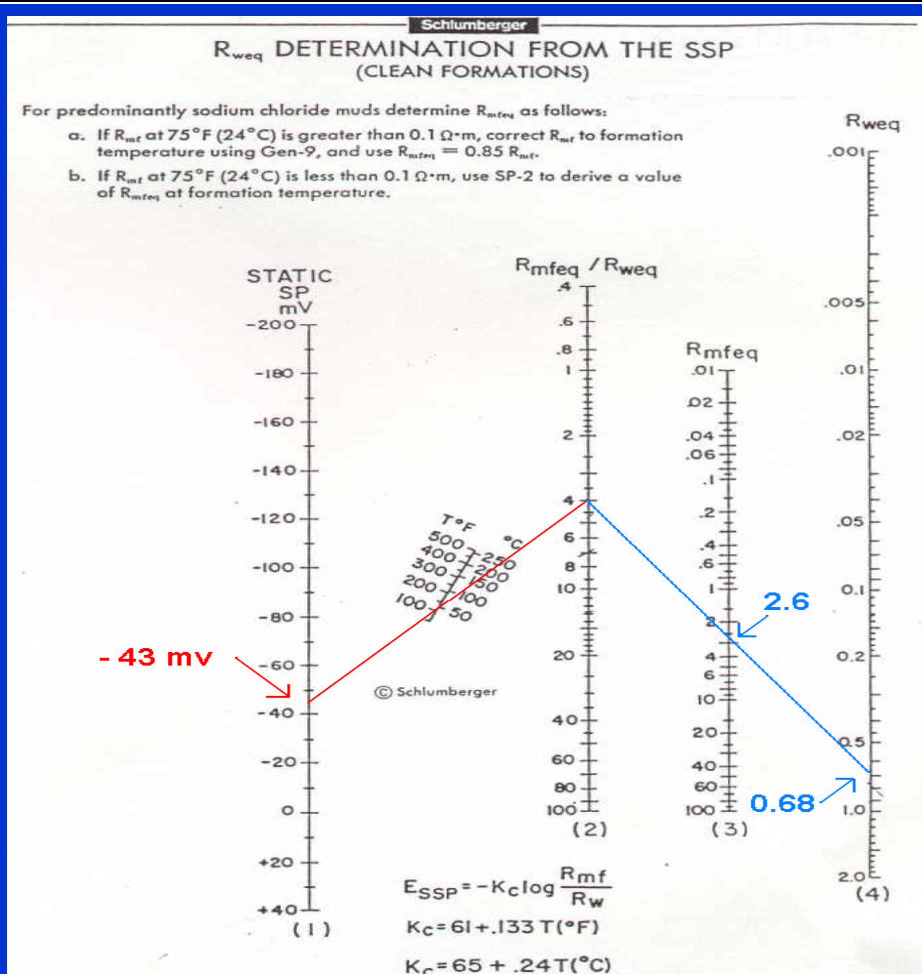
# SP Step 3: Pick SP Value




- Next, pick the value for SP for our example zone. Remember that the SP value is measured from the "shale baseline." Make sure that the SP deflection in the USDW is fully developed, that is, the bed is at least 10 times as thick as the wellbore, is water saturated, and shale-free. In our example case, we'd use a value of –43 millivolts.
- Remember that SP logs are relative to the salinity contrast of the mud filtrate and the formation water. Here, the mud filtrate is fresher than the formation water, and therefore gives a negative value. If the operator had used salt water mud, $R_w$ would be greater than $R_{mf}$ and we would get a positive reading for the zone.

# Step 4:

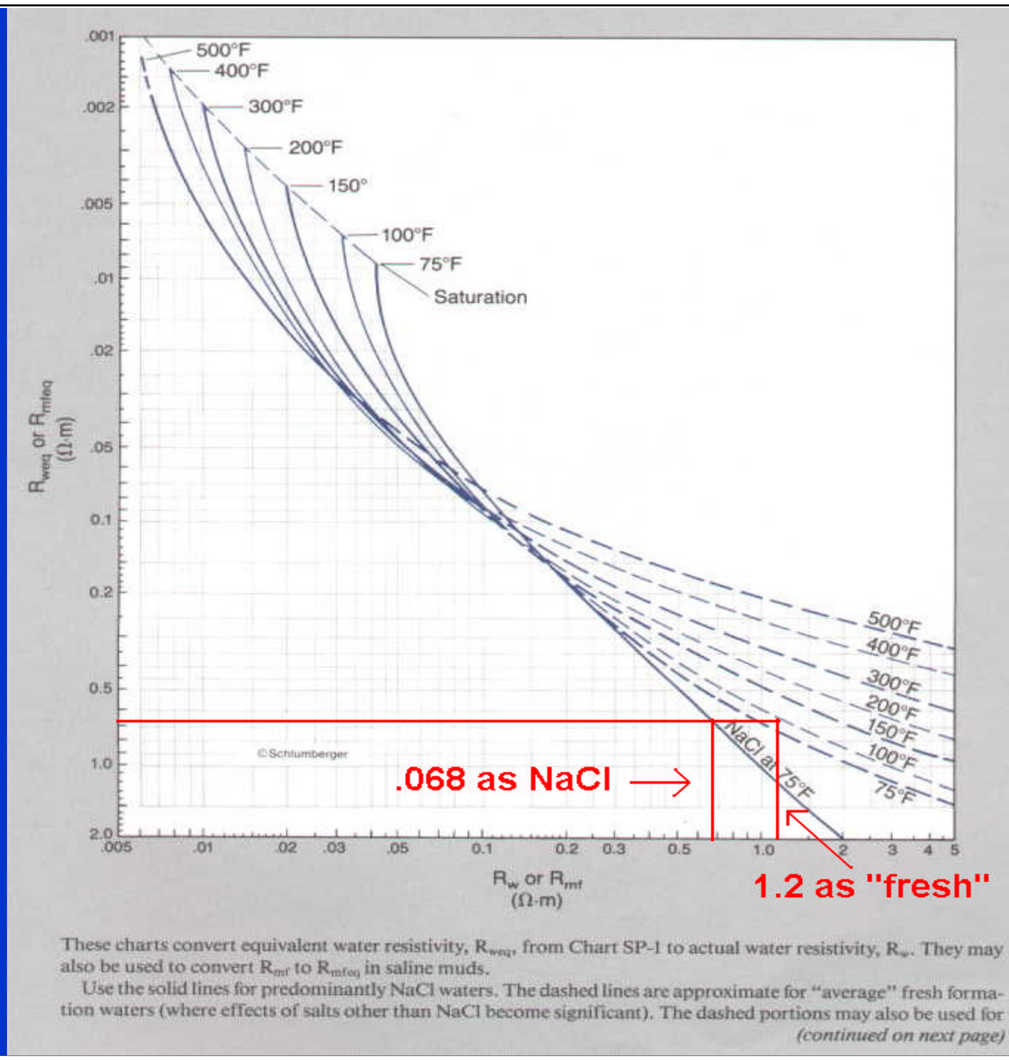
## Find $R_{weq}$




- Recall that $R_w$ is the natural resistivity of the formation water. $R_{weq}$ is the equivalent as SP, or spontaneous potential. To convert $R_{mfeq}$ to $R_{weq}$, use the nomograph. Using a straight edge, align the SP value from the log with formation temperature to find the ratio of $R_{mfeq}$ to $R_{weq}$. Then align that ratio with the value of $R_{mfeq}$ to find $R_{weq}$ in the right-hand scale.
- In our example, SP equals –43 mv and the formation temperature is 99 degrees F. Aligning these two values gives us a value of 3.9 for the $R_{mfeq}/R_{weq}$ ratio. Align that ratio with our value for $R_{mfeq}$ (previous slide, 2.6) and we get a result that $R_{weq}$ equals 0.68.

# Step 5:

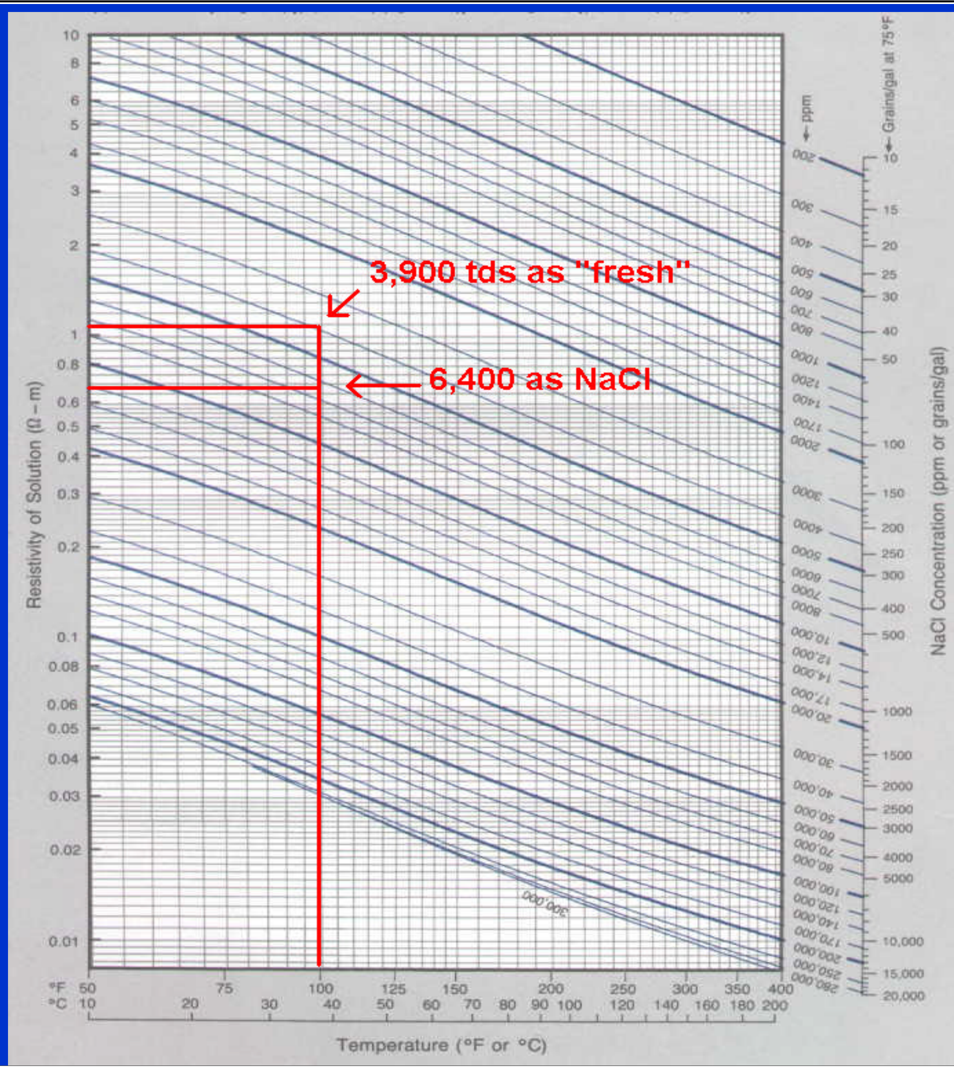
## Convert $R_{weq}$ to $R_w$




- Convert $R_{weq}$ to $R_w$ using this chart. Using the top-right corner of a sheet of paper, align $R_{weq}$ on the left axis (.68) with the appropriate temperature curve, and read down for $R_w$. Note that the dashed lines are used for less-saline aquifers. Rather than using the solute-specific multipliers we used for the resistivity method, we can use this shortcut for the SP method. Because most uses of the SP method are for fresh waters, Schlumberger prepared this table considering "average fresh water conditions." If you have a good idea of the water solute distribution, you can still use the NaCl curve here, find $R_w$, and then use the solute multipliers as before.
- We found that $R_{weq}$ equaled .68. Align the top edge with that value on the left-hand axis, and extend the paper until the top-right corner meets the NaCl line. The result measures $R_w$ as if the formation contained only NaCl, and $R_w$ equals .68. Now repeat the analysis using the 99 degree dashed-line. As fresh water, $R_w$ equals 1.2.

# Step 6:

## Convert $R_w$ to TDS




- This step is the same as that used for the Resistivity method. Align the paper with $R_w$ on the vertical axis and the formation temp on the horizontal. The intersection is read down and to the right on the iso-concentration line.
- In this case, as NaCl, we found that $R_w$ equals .68. Using the graph at 99 degrees formation temperature, the corresponding TDS of the zone would be about 6,400.
- As fresh water, $R_w$ equals 1.2, which corresponds to a value of about 3,900 ppm TDS if the zone contained fresh water. Remember that for TDS over 4,000, the true answer probably lies somewhere in between.

## Limitations of SP Method

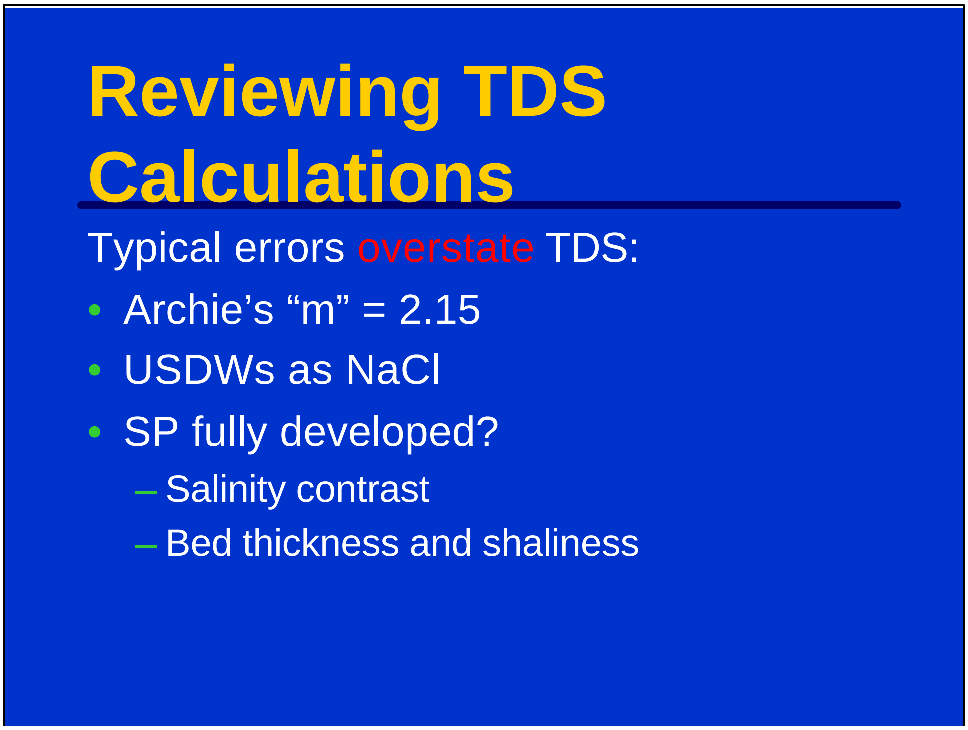
- Accuracy varies with salinity contrast
- Bed thickness and shaliness affect SP
- Accuracy of $R_m/R_{mf}$
- USDW components add more error for SP

- Theoretically, the SP method should be more accurate than the resistivity method, because we don't have to estimate "m" or calculate porosity.
- In practice, however, the SP method can be less accurate.
  - First, there has to be a good contrast between the salinity of the mud filtrate versus the formation water.
  - Second, bed thickness and shaliness affect the SP log values.
  - Third, the method is dependent on the accuracy with which the rig crew measured $R_{mf}$, the resistivity of the mud filtrate. Even in the case of an accurate measurement, mud properties are likely to change substantially as the hole is drilled and tools are run in and out of the well. $R_{mf}$ downhole may differ from surface values by 20 percent.
  - Last, the presence of calcium and magnesium in USDWs causes a larger potential error than is found with the resistivity method.

# Comparison of Methods

- Resistivity method
  - 4,100 TDS as fresh water versus 6,750 as NaCl
  - Must estimate porosity and "m"
- SP method
  - 3,900 as fresh water versus 6,400 as NaCl
  - Accuracy of $R_{mf}$ and salinity contrast

- Our estimates of the salinity in the zone compare reasonably well: 4,100 versus 3,900 as fresh water, and 6,750 versus 6,400 as sodium chloride. Both methods have drawbacks that affect accuracy. In the case of SP, there are fewer variables, but changes in $R_{mf}$ can introduce errors. In the resistivity method, the log is much more accurate, but you have to know something about the aquifer or the region to estimate "m," the cementation factor.
- What is the real salinity of the zone? Only a chemical analysis would tell for sure, but you should never consider any log estimate of TDS more accurate than +/– 10 to 15 percent.




- Having two people make these calculations independently resulted in differences of only five percent, but estimates using the same data may differ by several thousand mg/l. Here are the most common sources of error. Also keep these factors in mind if you need to review the TDS calculations made by others. These are the essential elements that are commonly omitted or confused.
    - First, Archie's original paper specified "m" as equal to 2.15. This is indeed true for the well-cemented sands in the deep-basin oil reservoirs that Archie wrote about. Several researchers since then, however, find that "m" is variable, and ranges from 1.3 to 2.2. Using 2.15 for "m" is a common error, usually made by consultants who would like to overstate TDS. "See, it's not really a USDW!" Beware.
    - The second most common error is not considering the composition of USDWs. Failure to convert $R_{weq}$ to $R_w$ in the SP method or not using solute multipliers in the resistivity method treats USDWs as if they were 100 percent sodium chloride, rather than containing, calcium magnesium, bicarbonate, and sulfate. This error also tends to overstate the TDS of the aquifer.
    - Third, you must be very aware of the salinity contrast between the fluid in the well and the native formation when using the SP method. For example, many operators in coastal areas use brackish estuary water for mud makeup. The resulting $R_{mf}$ salinity makes the development of a valid SP a little shaky in formations containing less than 10,000 TDS. Even in cases where operators use city water for mud makeup, development of a valid SP is possible only when there is a true salinity contrast. Always check the contrast between $R_w$ and $R_{mf}$. As the values approach equality, the SP method becomes less reliable.
- What is the net result of these common errors? They can result in overstating USDW salinity by 100 percent! Know your method and know its drawbacks.

# Lesson 6
# Aquifer Exemptions

- Attachment S of the permit application deals with the permit applicant's request for an aquifer exemption. This section of the training course will explain why EPA regulations have the exemption provision, the basic conditions that the applicant must fulfill to qualify for an aquifer exemption, and what the permit reviewer needs to consider and steps he/she must complete with regard to the aquifer exemption request.

# Why an Exemption?

- All USDWs to be protected except exempted aquifers
- If injection to occur into formation that technically meets definition, but practically is not a potential drinking water source, exemption process available

- An aquifer or a portion of an aquifer that otherwise would be considered a USDW can, based on the Federal definition, be exempted. Certain limitations on operations, siting, and monitoring may be less stringent or not applicable in the permitting process if an aquifer is exempted from consideration as a USDW.
- Why would EPA want to exempt an aquifer from protection? In some cases, a water bearing formation may technically meet the definition of a USDW, but the likelihood of it truly being used as a drinking water source is extremely remote. In practical terms, it may be unusable as a public water supply. Zones may exist that are significant mineral resources but meet the USDW definition. Or, an area may have abundant drinking water resources such that a formation with nearly 10,000 TDS would not be used as a potable water source.
- Without the exemption process, even if EPA acknowledged that a formation was a USDW in name only, not in practical terms, it still would be prohibited from receiving any fluid from a UIC well.
- In the exemption process, the applicant requests the exemption of the formation or part of a formation. A specific geographic limit can be placed on the exemption. The applicant must demonstrate the exemption is appropriate. The primacy or DI regulator reviews the applicant's request. In a primacy state, even if the state agrees with the request, it must then be forwarded to EPA's Regional Office for review and approval or disapproval.

# Basis for Exemption

- Criteria for exemptions in 40 CFR 146.4
  - Not currently serving as source of drinking water
  - Cannot now and will not in future serve as source of drinking water
  - TDS >3,000 mg/l and <10,000 mg/l, and not reasonably expected to supply public water system

- There are specific criteria that must be met for any portion of an aquifer to be designated as an exempted aquifer. As listed in 40 CFR 146.4, these are:
  - The aquifer does not currently serve as a source of drinking water; ***and***
  - It cannot now and will not in the future serve as a source of drinking water; ***or***
  - The total dissolved solids (TDS) content of the ground water is more than 3,000 mg/l and less than 10,000 mg/l, and the aquifer is not reasonably expected to supply a public water supply.

# Deciding about Drinking Water Sources

- How do I decide if the aquifer cannot now and will not in the future serve as a drinking water source?
  - Mineral or hydrocarbon resource?
  - Depth and location compared to technology and economics?
  - Contamination?
  - Subsidence or collapse likely from Class III UIC mining?

- The second criterion listed on the previous slide for an exempted aquifer requires that EPA determine that the aquifer cannot now and will not in the future serve as a drinking water source. Note that the rule does not say supply a public water supply, but rather "serve as a drinking water source." The regulation provides specific criteria that can be considered in deciding whether this is the case. The decision may be based on any of the following four specific situations regarding the aquifer. These situations are listed in 40 CFR 146.4(b)(1)-(4):
  - It produces mineral, hydrocarbon or geothermal energy, or the Class II or III UIC well permit applicant can demonstrate it contains minerals or hydrocarbons in quantity and location that are expected to be commercially producible;
  - It is situated at a depth or location that makes the recovery of the ground water for drinking water purposes economically or technologically impractical;
  - It is so contaminated that rendering the water fit for human consumption would be economically or technologically impractical; or
  - It is located over a Class III well mining area subject to subsidence or catastrophic collapse.

# Procedure for Exemptions

- Administrator and Regional Administrators have authority to approve exemptions (40 CFR 144.7(b)(2))
- Exemptions subject to public input
- Information requirements for Class II and III applicants in 40 CFR 144.7(c)

- Some exemptions require the Administrator's approval (if they are "substantial program revisions") while others can be approved by the Regional Administrator (those that are "non-substantial revisions"). Whether approvable by Headquarters or the Region, the bottom line is that the exemptions *cannot be completed by the primacy States alone*. To determine what type of revision an exemption request you receive may be, please be sure to check with your manager and appropriate counsel.
- The aquifer requested to be exempted may be identified by narrative description, illustrations, maps or other means. The aquifer or portion to be designated is also described in geographic and/or geometric terms (such as vertical and lateral limits, and gradient).
- All exemptions are subject to public input, through the issuance of public notice and opportunity for public hearings and comment.
- A primacy State UIC program may propose to the Administrator to exempt an aquifer based on the >3,000 mg/l and < 10,000 mg/l TDS criterion. If the State Director submits the exemption in writing to the Administrator and it is not disapproved within 45 days, that exemption automatically becomes final (see 40 CFR 144.7(b)(3)).
- For designations based on commercially producible minerals or hydrocarbons, the Class II or Class III applicant is required to submit information to the EPA to demonstrate the feasibility of the production. The specific information to be submitted by the applicant is detailed in 40 CFR 144.7(c).

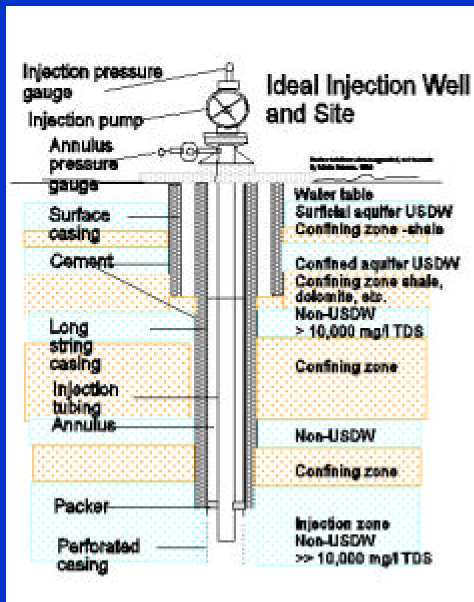
## Permitting Ramifications

- All USDWs are required to be protected by the UIC program
- Exempted aquifers do not receive this protection
- If a well does not penetrate or is not within 1/4 mile of a USDW, under §144.16 it can receive special treatment; Director can waive some of the UIC requirements
- The designation is a final EPA action
- All supporting documentation placed in Administrative Record

- It is important to realize that all USDWs, even if not specifically identified by name or location, are to be protected in the UIC program. The exemption that is designated for an aquifer is an exemption **from** protection.
- Many permitting requirements designed to protect USDWs, then, are no longer applicable as they relate to the aquifer once the exemption is made. Under 40 CFR 144.16, less stringent well permit requirements may be applied if injection does not occur into, through or above a USDW. So, in areas where USDWs are at least 1/4 mile from the well, or where the aquifers are exempted, a UIC well may be permitted less stringently. As we discussed earlier, the whole premise of the UIC Program is USDW protection - if no USDW is present to protect, then requirements can be less intense.
- If an aquifer is exempted, the exemption applies for all UIC wells, not just those of a particular class. It is very important to consider the information and ensure that the aquifer does indeed meet the regulatory criteria and is not subject to protection as a USDW. The *designation as an exempted aquifer is a final action of EPA*. As such, it is subject to the public participation requirements of EPA's procedural rules and it definitely is not something about which one can later change one's mind. Be certain that all paperwork supporting the decision is placed in the administrative record of the permit application.
- Many experienced UIC personnel have been involved in aquifer exemptions. If an applicant identifies the need for an aquifer exemption in a UIC application, the permit writer should consult with these experienced personnel to ensure that appropriate information is provided and that the proper procedure is followed.

# Lesson 7
# Reviewing Local Geologic Data

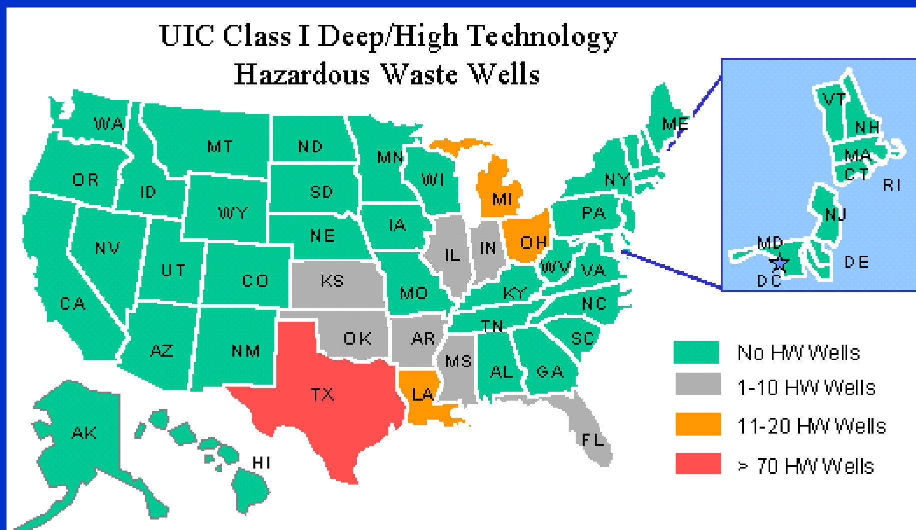
- Attachments F and G of the permit application require that certain details on the geology of the area around the well be provided. A brief summary of key terms and geologic relevance to UIC well siting are presented in this section. Additionally, we will discuss when Attachment F versus Attachment G is required, what data need to be submitted, potential data sources, and how all the data reviewed relate back to USDW protection.




# Definitions

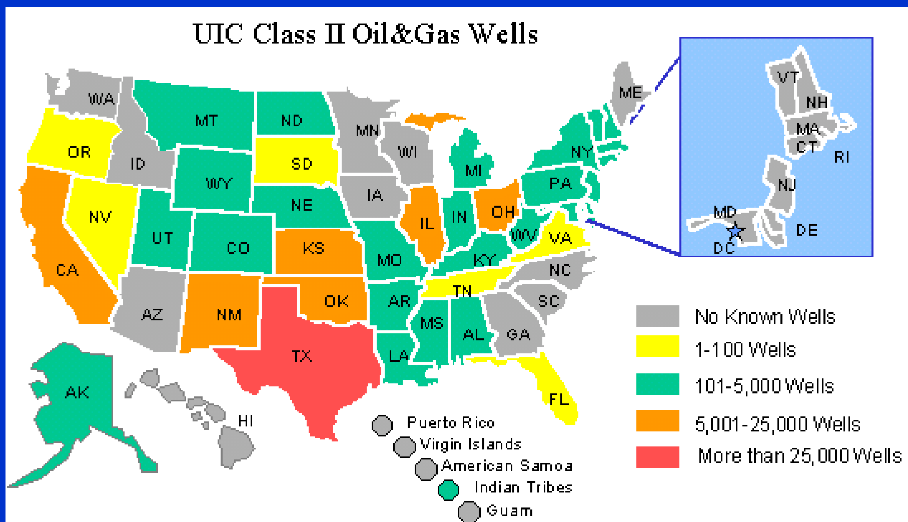
- A few terms need to be defined to understand the siting and other regulatory requirements of the UIC rules that relate to geology. In the UIC program, different terms apply to various formations that are found in the subsurface. The terms relate to whether the formations are allowed to receive any injection fluids and to various protective barriers intended to prevent contamination to underground sources of drinking water (USDW).
- The **injection zone** is a geological formation, group of formations or part of a formation receiving fluids through a well (40 CFR 144.3 and 146.3). The injection interval is that part of the injection zone in which the well is screened (completed) or in which the waste is otherwise ***directly*** emplaced.
    - o The injection zone as a whole may receive fluids, including indirect emplacement (migration) but the injection interval is the only part that can be designed for direct placement of the fluid.
    - o "**Injection interval**" is a term that only applies to Class I hazardous waste (Class I H - see 40 CFR 146.41(b)) wells in the regulations, but it is often used in other well classes as a descriptive term.
- The **confining zone** is a geological formation (or group or part of a formation) capable of limiting fluid movement above an injection zone (40 CFR 146.3). This rock layer (or layers) may have some fluid migrate into part of it, but the injectate is not intended to move beyond the confining zone over the entire life of the injection well's operation.
- The **containment interval** (also known as the arrestment interval) is not defined in the regulations.
    - o However, 40 CFR 146.62(d)(1) requires that the confining zone for a Class I H well be "separated from the base of the lowermost USDW by at least one sequence of permeable and less permeable strata that will provide an added layer of protection for the USDW in the event of fluid movement in an unlocated borehole or transmissive fault."
    - o This condition must be met unless there is no USDW or the pressure of the injection zone

# Injection in the U.S.

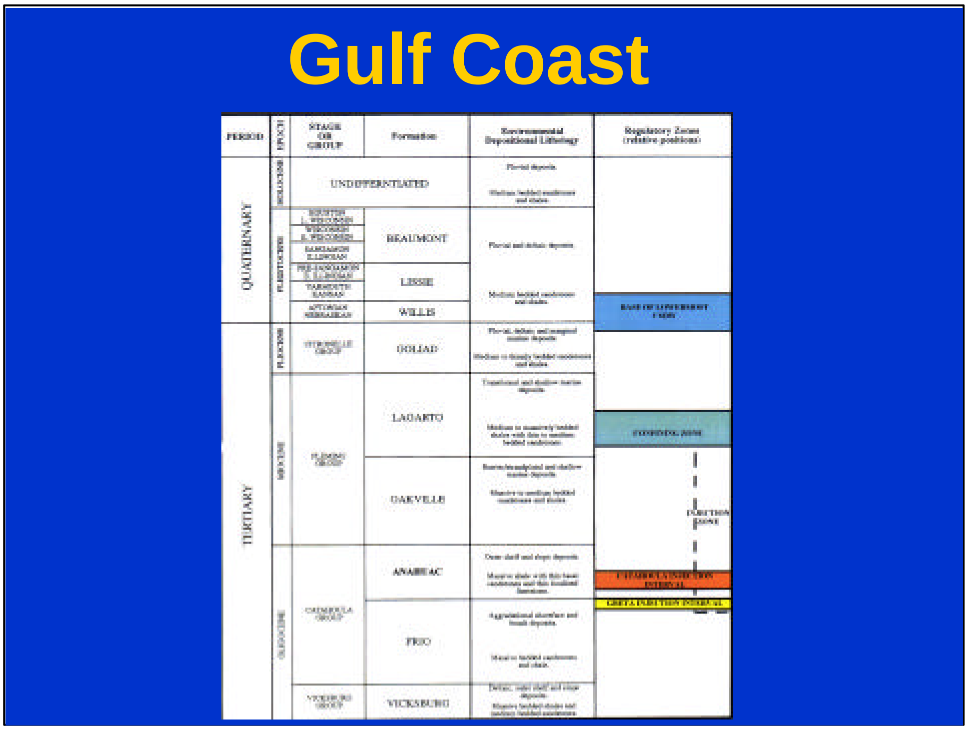



- Injection wells are known to exist in virtually every State. Class V wells, which typically are shallow, can be installed almost anywhere. Class I, II and III injection wells, however, tend to be clustered in specific geologic areas. These well Classes must be sited in locations that are suitable for receiving the fluids. The formations must have permeability and thickness sufficient for the well to accept a volume of fluid that will make the well economically viable. The formation must not be so brittle that fractures might develop or propagate during injection to endanger USDWs. Of course, these wells also are sited based on business need. A Class I well will be located where industrial or municipal wastes are generated in large quantities and need to be disposed. Class II wells are going to exist where oil and natural gas production and/or exploration occur. Class III wells will only be installed if minerals are mined using injection technology.
- The map above shows the distribution of Class I wells in the United States.

# Injection in the U.S.




- The Gulf Coast area, especially Texas and Louisiana, have large geographic areas that are geologically attractive for siting Class I, II and III wells. Region 6, with 184 Class I wells and more than 75,000 Class II wells has the greatest number of these wells among the 10 US EPA Regions.
- While Region 6 may top the list, Regions 3, 4, 5, 7, 8, 9 and 10 also have a significant number of these wells. Let’s briefly review the geology of the Gulf Coast and Ohio/Illinois/Michigan, where many injection wells are located.
- The above map shows the distribution of Class II wells in the United States.




- About 75 percent of all Class I injection wells are located in the Gulf coast region of Alabama, Mississippi, Louisiana, and Texas.
- Two hundred million years of subsidence and basin-filling in a tectonically inactive area resulted in over 20,000 feet of alternating marine shales and clean, deltaic sands. These formations are thick (up to 700 feet) and can be correlated for hundreds of miles using readily available data from oil and gas exploration.
- High permeability (up to 2 Darcies) in thick sand zones such as the 550-foot basal Frio formation yields high injectivity but minimal injectate plumes (on the order of a mile).
- Massive marine shales with immeasurably low permeability in the vertical direction and thicknesses up to 700 feet, such as the Vicksburg shale, ensure confinement under almost any injection circumstances.
- As a further safeguard, the alternating onlap-offlap cycles provide thousands of feet of additional confining zones and permeable “capture” zones between the confining zone and the base of USDWs. In addition, the geochemistry of marine clays makes them ideal candidates for adsorption of both organic and inorganic wastes.

# Ohio/Illinois/Michigan

STRATIGRAPHIC COLUMN
MIDWEST FUEL RECOVERY PLANT
GRUNDY COUNTY, ILLINOIS

| SYSTEM | ROCK UNIT | PREDOMINANT ROCK TYPE | ESTIMATED THICKNESS (FEET) |
|---|---|---|---|
| Pennsylvanian | Pottsville (?) | Sandstone | Variable, 80 feet total at one drill site. |
| Ordovician | Maquoketa | Limestone & Shale | |
| | Galena | Dolomite | 230 |
| | Platteville | Dolomite and Limestone | 115 |
| | Glenwood | Sandstone | 5 - 30 |
| | St. Peter | Sandstone | 165 |
| | Shakopee | Dolomite | 70 - 90 |
| | New Richmond | Sandstone and Dolomite | 45 - 55 |
| | Oneota | Dolomite | 210 |
| Cambrian | Trempeleau | Dolomite | 200 |
| | Franconia | Sandstone | 130 |
| | Ironton | Sandstone | 120 |
| | Galesville | Sandstone | 55+ |
| | Eau Claire Confining Unit | Shale | 400+ |
| | Basal Sandstone (Mt. Simon Aquifer) | Sandstone | 2,500+ |

- In Region 5, the Mount Simon Sandstone is the basal Cambrian unit in the Ohio/Illinois/Michigan area, and is commonly used for injection. Other formations may be used, depending on the fluid to be disposed and the location of USDWs. The Eau Claire Formation overlies the Mt. Simon, and may be included in the injection zone of some deep wells.
- The Mt. Simon is a high-energy shoreline facies of the northerly transgressing Cambrian sea (Catacosinos, 1973). It was deposited over the eroded Precambrian units below. It is a coarse-grained to conglomeratic sandstone, that frequently has sufficient thickness, permeability and porosity to serve as a long-term injection interval. The Mt. Simon is as thick as 2,000 feet in northwestern Indiana, and thins to an effective injection interval thickness of less than 100 feet in northeastern Ohio. The formation is known by this same name and is found as a continuous formation in Illinois, Wisconsin, Michigan, Ohio and Kentucky and is known as the Lamotte Sandstone in Missouri (Indiana Department of Natural Resources Geological Survey Bulletin 59, 1986).
- In contrast to the high permeabilities of the Gulf Coast sands, a permeability of 300 milliDarcies (0.3 Darcies) is considered quite good for the Mount Simon Sandstone in parts of Region 5.

# Other Locales

- A significant number of injection wells, especially Class II wells, exist in other locations
  - Appalachian Basin
  - Rocky Mountain Basin
  - Alaska
  - California

- Oil and natural gas production in the Appalachian Basin, Rocky Mountain Basin, Alaska, California, and other locations has created a need for Class II wells.
- The rock characteristics of these areas are very different from the Gulf Coast, with formations often being much more tight and brittle.
- The reviewer of a permit application in any locale must ensure that the information presented in the application is current and accurate. Only with accurate geologic information can the permit writer be certain that the well is properly constructed and operated to protect the subsurface environment that contains drinking water sources.
- Data in the vicinity of the proposed well site is especially important. The permit reviewer should ensure that data from nearby locations is not overlooked. It may be helpful to check private data base services, such as the API database, to acquire the most current and comprehensive data.

# Local Data

- Review of data near the well site is critical
- Nearby wells provide wealth of information
- Review of local data must be current

- With the variability in geology that occurs from one part of a State to another, let alone within a Region, it is imperative that the permit application present all available relevant data regarding local geology.
- Other wells may have been drilled near the well site and can be reviewed. Data may include cores, drill stem tests, well logs, and other well-specific test results. These data may be used to help determine the depth, thickness, salinity, and productivity of USDWs; lithologic variations, thickness and permeability of proposed injection and confining zones; elastic properties of the injection and confining zones; and other information that is useful in evaluating the site.
- Even for a renewal permit of a currently operating well, the local data must be checked to ensure it is current. New wells may have been drilled or additional information collected from an existing well since the time the original permit was developed. This new information may cause EPA to apply different conditions to the renewal permit compared to past permits.

# Well Site Evaluation for USDW Protection

- Formations free of intersecting faults and fractures
- No inadequately constructed or plugged wells penetrating into the confining or injection zones
- Injection pressure limited to prevent fracture creation

- There are multiple ways that injected fluids could get into a USDW to endanger it. The review of geologic data helps ensure that natural conduits do not exist that may endanger a USDW.
- It is important that the formations intended to seal the injection interval from the USDWs are free of intersecting faults and fractures. If faults or fractures are present, the injected fluid, introduced into the injection interval at an elevated pressure, will seek the path of lower pressure and move upward into a USDW.
- The same is true about the presence of other wells within the zone around the well that is subject to increased pressures as a result of injection activities. These could be old oil and gas exploration or production wells, or other injection wells that are not in use. The permit applicant is required to do a records search for other wells within a set radius around his or her injection well, and must evaluate all geologic information for the site to provide the greatest degree of certainty that paths for upward migration to USDWs are absent. The mere presence of a well does not mean there is a problem. However, wells that have not been adequately constructed or plugged can cause serious problems. We'll talk in more detail later in this course about these man-made conduits and how an applicant may find.
- The injection pressures applied within the permitted well must be limited such that fractures are not created or extended. This also ensures protection of USDWs. We will discuss appropriate operating pressure limitations in more detail in Lesson 14 of this training module.


- If a thorough evaluation is not done and an undiscovered deep well, fault or fracture system is present, or appropriate containment is absent due to the lithology of the area, a USDW may be threatened. As has been documented for years, preventing ground water contamination is much less costly than remediation. And if an injection well contaminates a USDW, it may be a long term source of ongoing contamination. The upward migration will occur as long as the conduit is present and the pressure in the injection interval is high enough to be a driver.
- To ensure safe UIC well injection, multiple barriers are needed to protect USDWs. The geologic data reviewed as part of the permit application are one piece in ensuring that the site meets the protective requirements of the regulations. Construction details, operational procedures and well monitoring provide additional protection. We will talk about each of these aspects later in the course. Keep in mind that all those issues come back to ensuring that injected fluids are not able to make their way into and contaminate a USDW.

## Geologic Data Requirements

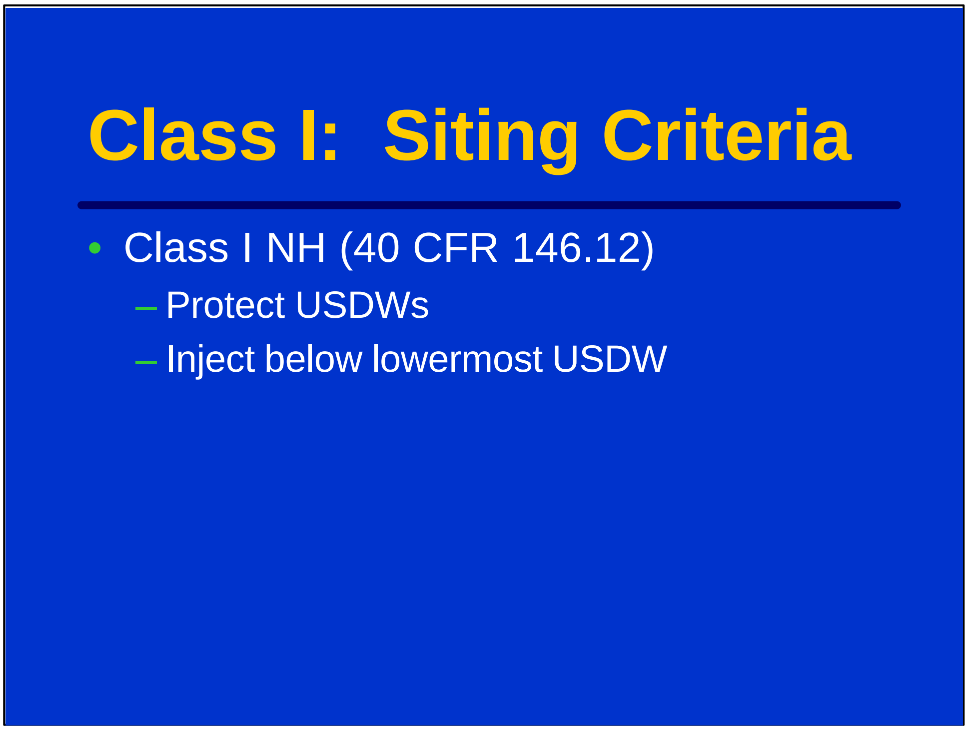
- Attachment F for Class I and Class III wells
  - Maps and cross-sections detailing local geology
  - Generalized cross-sections and map of regional geology
- Attachment G for Class II wells
  - Descriptive data for injection and confining zones

- Attachment F must be in a permit application for a Class I or Class III injection well. This Attachment is required to include both maps and cross-sections detailing the geologic structure of the local area. The lithology of the injection and confining intervals must be shown in detail on these maps and cross-sections.
- Class II injection well permits, on the other hand, are required to include Attachment G. Maps and cross-sections do not have to be included. Instead, geologic data for the injection and confining zones are to be submitted. This includes a lithologic description for both zones, geological names for the formations included in the injection zone and confining zone, and the thickness, depth and fracture pressure of each of these formations.

## Injection Well Site Evaluation

- Siting requirements differ by well type
- Purpose of reviewing site-specific geologic and injectate information
  - Ensure minimum siting criteria are met
  - Determine the interaction between the subsurface and the injectate
  - Determine need for site-specific requirements

- Siting requirements differ by well class and type. Regulations for Class I hazardous waste (Class I H) injection wells have the most stringent siting requirements, and Class V have the least stringent. As with all injection activities, a well is not allowed to contaminate a USDW.
- The permit writer's responsibility is to review the information in the permit application in order to establish permit conditions that ensure that the non-endangerment standard and all other applicable requirements will be met. Site evaluation is one important aspect of this review.
- As we have seen, the permit application provides site-specific geologic information. The permit writer must review it to ensure that the minimum siting criteria are met. He or she may need to impose additional requirements if questions arise as a result of the review process (such as collecting seismic data or placing operating restrictions on the well) or may deny the permit if the siting does not meet the standards.




- Class I nonhazardous (Class I NH) injection wells inject below the lowermost USDW within 1/4 mile of the wellbore, by definition (see 40 CFR 144.6(a)) and by the regulatory siting requirement (40 CFR 146.12(a)).
- The permit writer will evaluate the information submitted to make sure that all USDWs are properly identified, that any risks posed to USDWs by operation of a Class I NH well are adequately determined and addressed by the application, and that the geology of the area is characterized adequately to allow the permit writer to determine appropriate and protective construction and operating requirements in the permit. For a new well construction permit (permit to drill), the permit writer needs to determine if EPA needs additional information to establish operating conditions in an operating permit. The permit to drill should be carefully written to ensure that any additional site-specific geologic data will be collected during the drilling and construction of the well.

# Class I H: Siting Criteria 40 CFR 146.62

- Injection zone: permeability, porosity, thickness and areal extent to prevent migration into USDWs
- Confining zone
  - Laterally continuous and free of faults or fractures
  - At least one formation capable of preventing vertical fracture propagation
- At least one sequence of permeable and less permeable strata (containment interval) between confining zone and base of lowermost USDW or no USDW

- The injection zone of a Class I H well must have sufficient permeability, porosity, thickness and areal extent to prevent migration into USDWs.
- The confining zone must be laterally continuous and free of faults or fractures, and must contain at least one formation capable of preventing vertical fracture propagation if the fracture pressure of the injection zone were to be exceeded.
- The containment interval (arrestment interval) we discussed earlier also is required to be present.
- Significant site-specific information is required to ensure all these requirements are met, and modeling is conducted to depict various impacts of the well's operation over its anticipated operating lifetime. Modeling training for Class I wells is not included in this course. However, the process is very important in assuring that Class I hazardous waste injection wells wells are sited and operated safely. If you are responsible for reviewing models, you may want to seek additional training on that subject.
- As discussed for Class I non-hazardous injection wells, if the permit to drill application lacks some geologic details that will be necessary to establish operating conditions for the well, the permit to drill should specify what additional data needs to be collected. The permit writer must always look ahead in this situation, to ensure that an opportunity to collect essential data is not missed, since many types of data cannot be collected once the casing is set in the well.

# Classes II, III and V: Siting Criteria

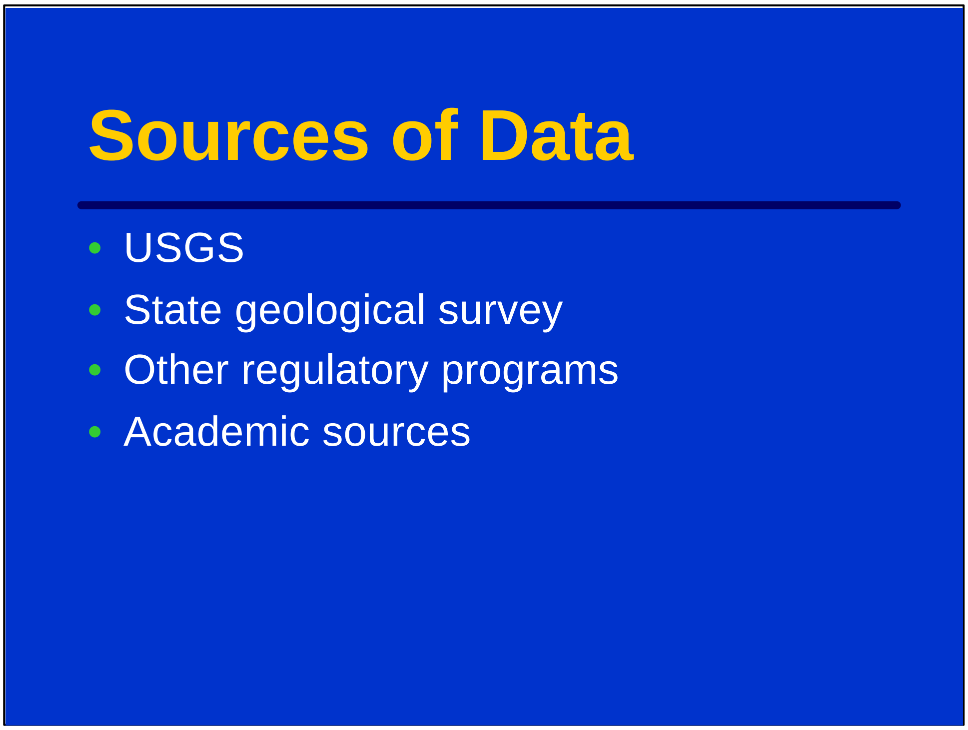
- Class II (40 CFR 146.22(a))
  - Separated from any USDW by a confining zone
- Class III and Class V (40 CFR 144.12)
  - Subject only to non-endangerment provision

- Class II wells must be sited so that they inject into a formation that is separated from any USDW by a confining zone free of known open faults or fractures within the designated area of review. This requirement is found at 40 CFR 146.22(a).
- No specific siting requirements are listed in Subpart D of 40 CFR Part146 for Class III wells. These wells are sited in a variety of geologic locales and situations in order to extract minerals from the subsurface. The regulations concentrate more on proper construction, operation and monitoring. However, the permit review process includes a detailed geologic review as we discussed earlier. If the data indicate that a well's presence would threaten USDWs, then the permit writer must detail the facts and present them to the applicant in the form of a comment letter or Notice of Deficiency, in light of 40 CFR 144.12. The applicant may need to collect additional data or conduct different tests in the well. As with any well type, if EPA determines in the end that the well will endanger USDWs, then the Agency has to deny the permit. (The procedural process for Agency permitting actions will be discussed in detail later in the course.)
- Well construction requirements must be included in the permit to ensure USDWs are adequately protected during the Class III project's operation (see 40 CFR 146.31).
- Similarly, the rules for Class V wells do not include siting criteria. Instead, the permit writer focuses on overall protection of USDWs, and must base a permitting decision on that standard.

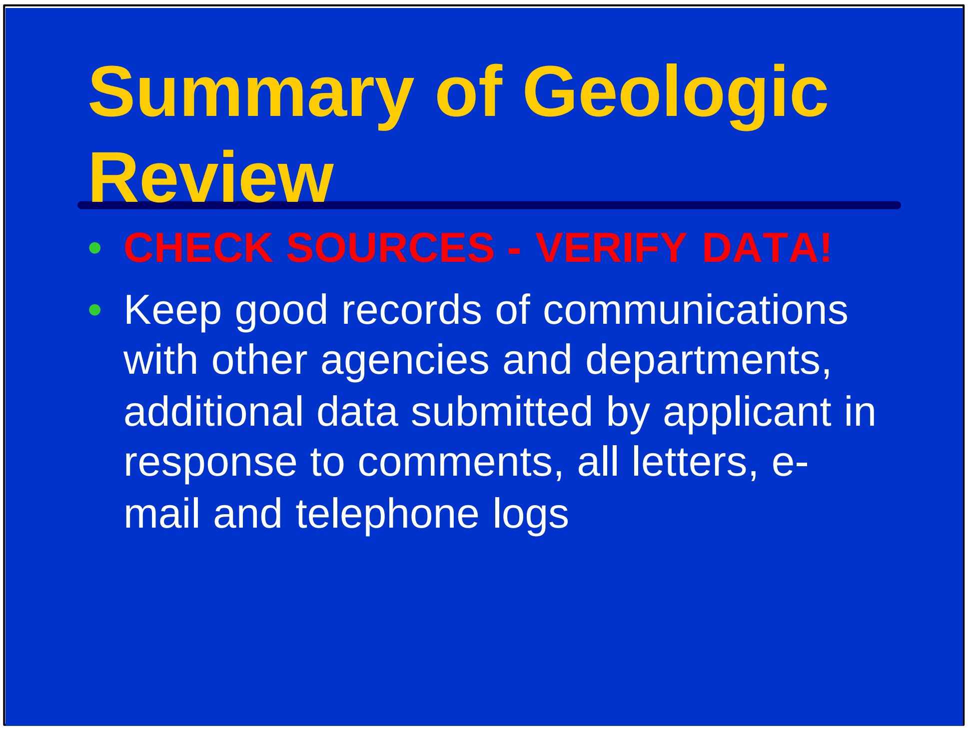
# Other Non-UIC Siting Issues

- RCRA regulatory requirements for hazardous waste
- Federal laws listed at 40 CFR 144.4
- Source water protection or wellhead protection area limitations
- Zoning restrictions

- Other Federal or State regulations or local ordinances may affect the siting of an injection well. While the UIC program will not generally write them into the permit explicitly, permit writers should be aware of them since these issues likely will be raised by the affected public. They include:
  - The Resource Conservation and Recovery Act (RCRA) regulates treatment (including filtration) and storage of hazardous waste. Under RCRA, siting criteria include limitations on locating near floodplains and seismic areas. For certain types of wastes, setbacks from property boundaries are specified for storage and accumulation. These are just a few examples of limitations that RCRA may impose on siting a hazardous waste injection well or facility. Such permitting overlaps demonstrate the importance of reviewing other permits that are applicable to the facility (see Lesson 3 - Existing Permits) and coordinating with other program personnel so EPA's actions for the facility are consistent.
  - As discussed in Lesson 2 of this course, 40 CFR 144.4 lists five major Federal statutes that can significantly affect UIC permitting.
  - If an injection well is to be sited in an area that has an established Source Water Protection Area or Wellhead Protection Area in place, limitations may be placed on the ability to install the well. The local governing authority would implement these restrictions.
  - Zoning may prohibit the installation of various kinds of facilities, including injection wells. Again, the local governing authority will exercise any zoning restrictions regarding the site.




- The U.S. Geological Survey (USGS) is a resource for both regional and local geology. The State geological survey can provide information regarding regional and local geology, well logs and records and historic information on drilling and mineral resources in the area.
- Other regulators may be able to provide information of value as well. Check to see if other classes of wells have been drilled and permitted in the area, if the drinking water program has information relevant to USDWs, and if any special geologic studies have been required for siting of hazardous waste or solid waste facilities.
- Academic sources can provide extremely current and useful information. Check with universities and colleges in the area to see if a PhD or Master’s student has studied relevant geologic issues for the area. Of course, the Internet can provide helpful resources from academic and government sources as well.




- When it comes to the geologic data, be absolutely certain that generalizations are not inappropriately applied to the site that could affect the geologic characteristics that make the site suitable for injection well siting. Poor siting can have a huge, long term effect on USDWs.
- Always take the time to check data sources and verify the information presented. Review the references used by the applicant to see if recent publications and information were incorporated. A few short e-mails, faxes or notes to other Federal or State personnel can help you ascertain if additional relevant facts need to be reviewed.
- Ensure that your communications with others regarding confirmation of the data are carefully recorded in the administrative record, along with any additional data the applicant submits or you discover in your review. All the critical information that is used to support the Agency's action on the application must be documented in the record so the basis of the decision is clear.