# XI. PLUGGING AND ABANDONMENT OF OIL AND GAS WELLS

## A. INTRODUCTION

The plugging and abandonment of oil and gas wells is an operation that is critical for the protection of underground and surface waters. Proper plugging procedures must be followed to effectively block the migration of oil, gas, brine and other detrimental substances into freshwater aquifers. The infiltration of water into oil and gas reservoirs must also be prevented to avoid damage to these resources.

State law requires operators of most oil, gas and solution mining wells in New York State to maintain financial security with the Department to ensure that the wells are properly plugged and abandoned after their economic life is over. Financial security requirements were substantially increased in 1985 to more closely match the actual costs of plugging operations.

An owner, which means the person who has the right to drill into and produce from a pool, may not transfer his plugging and abandonment responsibilities by surrendering a lease [ECL 23-0305.8e]. These requirements are the owner's responsibility and are assumed at the time a well is permitted for drilling. However, these responsibilities may be transferred upon the agreement of parties involved. DEC must approve the transfer, and the transferee must show financial security for his/her well plugging responsibility. A prescribed transfer form is available from the Department.

Wells are commonly plugged either because they are dry holes or they have ceased to produce economic quantities of oil or gas. A well may also be plugged if severe problems are encountered during drilling. The Department may also order a well plugged because of environmental or safety problems. From an engineering standpoint, the purposes of plugging are to: 1) prevent the mixing of fluids from different geologic levels, 2) prevent the flow of

fluids from pressurized zones to the surface, and 3) maintain pressure integrity in the individual subsurface intervals. Since the entire wellbore is a potential channel for fluid movement, wells must be plugged with cement at several locations. Under most conditions the intervals in between cement plugs should be filled with a heavy mud or other approved fluid. In general, cement plugs are placed: 1) at the ground surface, 2) above and across all oil and gas zones, 3) atop casing stubs if any casing strings are recovered and 4) across the base of the surface casing or below the base of the freshwater zone. No contiguous annular spaces are allowed to remain. When uncemented casing is left in the hole, it must be ripped or perforated and have cement squeezed into the annular space behind it.

Once the well is plugged, the site must be reclaimed by removing equipment and grading the surface to match the surrounding areas. **In agricultural areas, the casing must be cut off below plow depth (approximately 4 feet). The topsoil cover must be replaced and the site must be seeded to re-establish vegetation.**

B. PLUGGING REGULATIONS

1. Old Plugging Regulations

Though New York State has had laws requiring the plugging of oil and gas wells since 1879, operators were not required to obtain a state permit before they could plug and abandon a well until 1966. Until the State's Oil and Gas Law was amended in 1981, wells drilled in fields that had been discovered prior to October 1, 1963 could be legally abandoned with seasoned wooden plugs. Wells drilled in fields that were discovered after October 1, 1963 were subject to much more stringent regulations requiring cement plugs. Wells abandoned before comprehensive state regulation have been plugged according to the state of the art at the time - usually brush or

wooden plugs. Although operators used wooden plugs or other techniques in good conscience, many old abandoned wells have caused serious localized environmental problems.

2. Existing Plugging Regulations

Title 6, Chapter 5, Subchapter B Part 555, Sections 1-6 of the New York State Department of Environmental Conservation (DEC) regulations deal with the plugging and abandonment of oil and gas wells.

These regulations are not very specific or comprehensive, but the 1981 amendments to the Oil, Gas and Solution Mining Law gave DEC broader power to regulate the industry. Until new regulations are written, it has been the Department's policy to add specific safety and environmental conditions to individual plugging permits as needed.

3. Summary of the Existing Plugging Requirements

Current regulations specify that a cement plug be run from total depth to a minimum of 15 feet above the shallowest producing zone, and/or a cement plug of at least 15 feet on top of a bridge placed above each formation from which the production of oil and/or gas has been obtained in the vicinity. If any casing is left in the ground, a plug of at least 15 feet must be placed at the bottom of the casing; and another 15 foot plug must be placed at the top unless the casing extends to the surface. Also, if any casing extending below the deepest potable fresh water is removed, a 15 foot plug must be placed in the open hole approximately 50 feet below the deepest potable water. All the intervals between plugs must be filled with a heavy mud, "gel" or approved fluid. Fluid is required so that there is sufficient hydrostatic pressure exerted to exceed any zone pressures found in the well, and thus prevent the movement of other fluids into the wellbore. All casing extending to the surface must be capped in a manner that will prevent the migration of fluids and not interfere with soil cultivation. (See figure 11.1 for further

explanation).

C. MUDDING THE HOLE

The combination of properly placed cement plugs and mud in the wellbore can be a more effective method of permanently abandoning a well than a rigid column of cement from total depth to the surface which could develop a micro-annulus with hydration and time. A natural bentonite mud is the best mud for abandonment because it has good gel-shear strength. It also is less likely to separate with time and leave a water column suspended above the mud or "gel" solids. **It is recommended all portions of the hole not plugged with cement be filled with a clay base mud with a minimum density of 8.65 ppg and a gel-shear strength (10 min.) of 15.3 to 23.5 lbs/100 sq. feet. Exceptions to this requirement will be reviewed on a field area basis.**

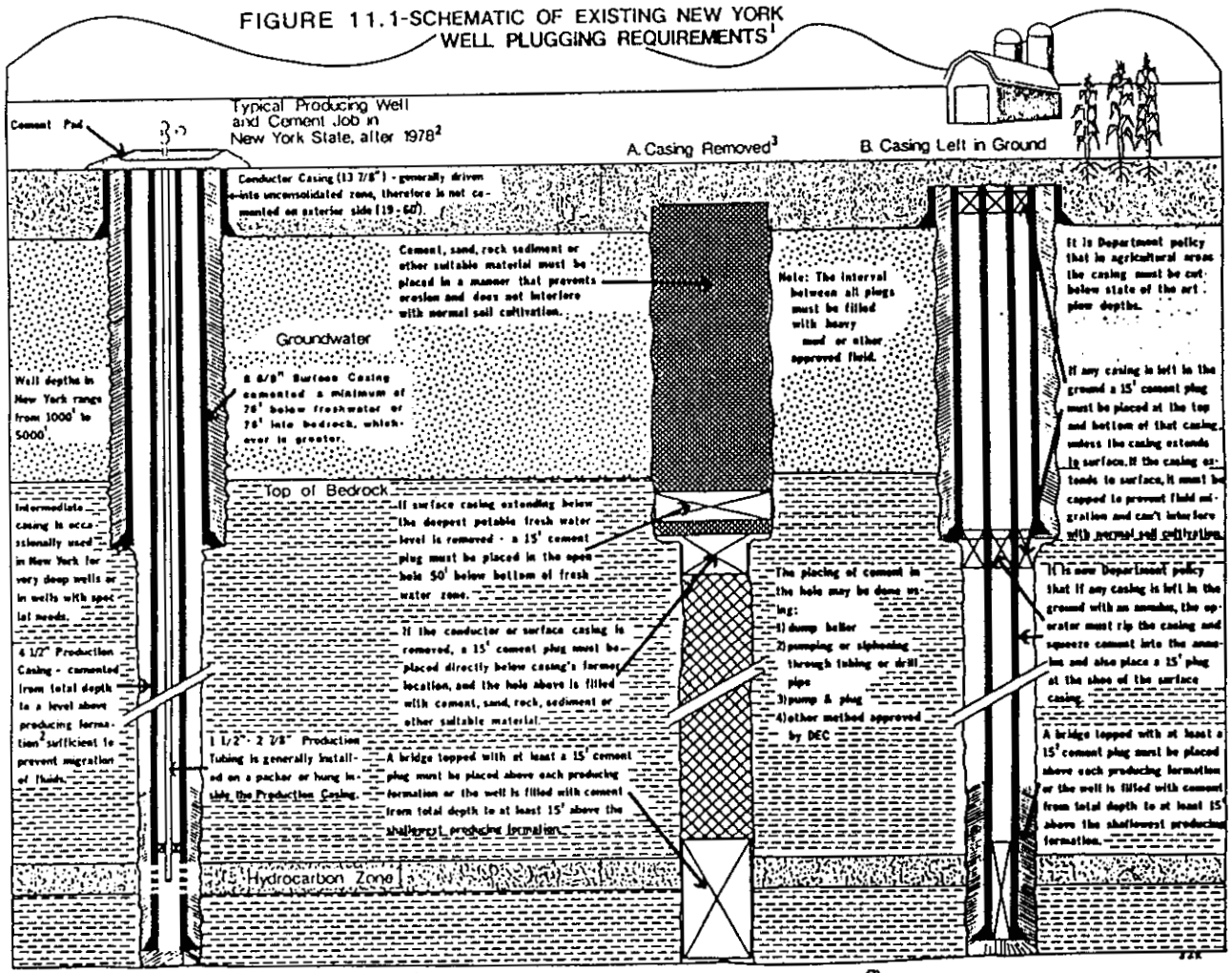
D. PLUGGING METHODS

There are several plugging methods used to abandon wells.

1. Dump bailer
2. Pumping or siphoning through tubing or drill pipe (Balance Method)
3. Mechanical bridge

Briefly, the first method consists of lowering a dump bailer containing a measured amount of cement down the hole where the cement is released when the bailer hits a bridge plug previously set at the desired depth. This plugging method requires a minimum of equipment. Therefore, where the access road and well location are restricted, plugging the well with a dump bailer may be preferable. The second method involves running tubing into the hole to the desired depth and pumping through it, a measured amount of cement. The cement is then partially displaced out of the tubing by pumping mud, water or other approved fluid behind the cement slurry. When the level of cement outside the

FIGURE 11.1-SCHEMATIC OF EXISTING NEW YORK WELL PLUGGING REQUIREMENTS[1]




(1) Permit conditions can be used to modify or add to individual well plugging requirements in order to address special conditions.

(2) Special requirements apply to Bass Island & aquifer wells that are not detailed in this diagram. Also variations exist in fields established before 1963. However, the plugging requirements for all of these wells are roughly the same.

(3) Usually the lower portion of the Production Casing & part of the Conductor & Surface Casing is left in the ground, in most cases it is difficult & expensive to remove all of the casing from the well.

FIGURE 11.1

tubing is equal to that inside, the pipe is slowly pulled from the cement slurry. Both the pumping through tubing and the dump bailer methods of setting plugs are subject to contamination which can keep the plugs from setting. A small dump bailer plug can be contaminated by the presence of mud or other fluids even in a static hole, and if the well has not been adequately killed, a plug pumped through the tubing can be contaminated by the movement of borehole fluids or gas bubbles channeling through the plug. The most commonly used techniques for plugging wells are the mechanical bridge method and the balance method. The mechanical bridge method is the most common method used to plug oil wells, and the balance method is the most commonly used method to plug gas wells.

In the mechanical bridge method, a bridge plug is set in the hole or casing just above the zone or formation to be plugged. A bridge plug is a type of mechanical packer which is generally permanent though some are retrievable. Once the bridge plug or packer forms a bridge across the well, sealing off the well below, cement is placed on top of it.

A variation on the balance method consists of filling the borehole with mud or "gel" and spotting cement plugs at the desired depth. Small volume cement plugs set by all of these methods can be contaminated by mud, fluid movement or gas. For this reason, an increase in plug length and/or tagging the location of critical plugs is recommended.

Occasionally, an operator finds it cost effective to abandon a shallow gas or oil well by using bullhead or braden head squeeze techniques to pump the entire wellbore with cement. This method can save time and the only equipment that is needed are cement pump and bulk trucks and a water source. An operator choosing this abandon method should add a small percentage of bentonite to the bulk cement to reduce dehydration and shrinkage which might create a micro-annulus.

## E. ADDITIONAL PLUGGING REQUIREMENTS

Sometimes casing is recovered from the well before abandonment. When casing is to be recovered, the top of cement in the annular space is determined by running a cement bond log or some other free point indicator such as a strain gauge. Once the top of cement has been determined, the casing is cut above that depth and removed from the hole. Then either a bridge plug is set (mechanical method) or a cement plug is pumped in (pump and plug method). If the pump and plug method is used, the operator is required to run an extra quantity of cement to compensate for possible loss of cement in the casing-hole or casing-casing annular space below the cut. **Unless the operator can document conditions such as a major lost circulation zone, extreme corrosion or partial casing collapse, etc., which would make uncemented surface casing recovery inadvisable, an attempt must be made to recover uncemented casing. In the event uncemented casing cannot be recovered from the hole, it must be perforated or ripped and have cement squeezed or placed into the annular space.**

### 1. Site Reclamation

Site restoration is an essential step in the abandonment process for mitigating surface environmental impacts associated with oil and gas development. Failure to adequately restore a site can lead to severe soil erosion and siltation of surface water bodies. These impacts result in the return of less productive land to agriculture, wildlife habitat and other productive uses.

After the well has been plugged, the casing cut below plow depth in agricultural areas, and equipment and debris removed, the site must be restored as soon as is reasonably possible to its original condition. The mouse hole, rat hole and any other excavations made during drilling or

production must be filled. In some cases, the wellsite must be bulldozed or otherwise shaped similar to the adjacent terrain. To prevent potential erosion problems, operators are required to avoid creating undue elevations in the ground surface.

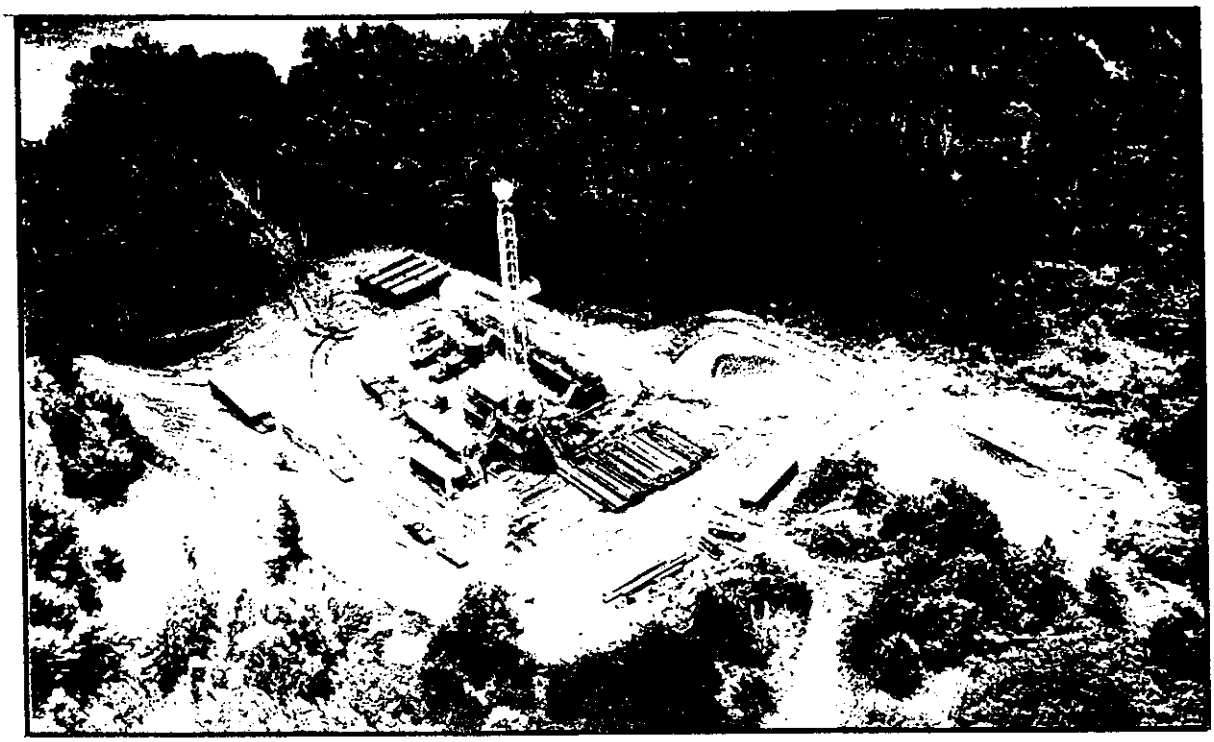
Although it is not specifically required in the regulations except in Agricultural Districts, operators are encouraged to set aside all topsoil removed during site construction so it can be replaced when the well is abandoned or the well site is restored after drilling. Mishandling of topsoil usually results in poor or sterile soil conditions which restrict re-vegetation of the area. Operators are required to seed the site to establish new vegetation and hold the soil in place when there is a potential for severe erosion damage. Figure 11.2 depicts a well site during drilling and after proper reclamation.

2. Potential Delays in Plugging and Abandonment

a. Shut-in - For practical reasons, wells do not operate continuously throughout their producing life. Production is commonly shut-in several times a year for routine repairs or maintenance. Production may also be suspended if a market for the well's oil and/or gas is temporarily unavailable. The potential exists, however, for extending a routine shut-in of operations into an excuse to abandon a well without going to the expense of properly plugging it. To prevent such abuses, the regulations prohibit operators from shutting-in wells capable of commercial production for more than one year without specific permission from the Department.

Upon written application by the owner or operator, demonstrating sufficient good cause, the Department can administratively grant a one year extension. Additional extensions may be granted if the need can be substantiated. Once the period of lawful shut-in ends, the owner or operator must begin producing the well or permanently plug and abandon it.

# FIGURE 11.2 - WELL SITE AFTER PROPER RECLAMATION



BEFORE - Columbia's Finnegan No. 1 well was spudded on July 22, 1983 in the rural countyside of the Town of Easton, Washington County. Because of its greater depth (7,764') than most New York State wells, both the rig and its support facilities were larger than usual. This is an aerial view. This wellsite was barely visible from the ground because of all the trees.

AFTER - As shown in this photo taken roughly 2 1/2 years after the well was plugged, no signs remain of the extensive drilling operations. Division of Mineral Resources, petroleum engineer, Richard Arieda is standing directly over the old well location.

FIGURE 11.2

b. Temporary Abandonment - Delays in operations may also occur during the drilling and completion stages of the well. It is not uncommon for work to be suspended while logs, core samples and other data are analyzed to see if completion of the well is warranted. Economic factors may also lead operators to delay perforating and hydraulically fracturing a potentially good well. Service companies charge for time and mileage, making it cheaper to wait and have several wells in one area perforated and stimulated at the same time.

As with the shut-in of producing wells, the accepted temporary delays in drilling and completion can be abused to avoid the expense of properly plugging and abandoning a non-commercial well. Therefore, the existing regulations prohibit the owner or operator from temporarily abandoning a new well for more than 90 days unless the Department grants an extension. The Department can administratively grant extensions for a reasonable time period.

c. Detection of Illegal Delays in Plugging - During a shut-in or temporary well abandonment the operator is still responsible for compliance with all Department regulations, including those requiring submission of Well Drilling and Completion Reports and Annual Well Status and Production Reports. Illegally shut-in wells can be found by reviewing the Annual Production Reports. Temporary abandonment of wells for more than 90 days may be indicated by lack of a Well Drilling and Completion Report for a well that is believed to have been drilled. The ongoing computerization of these records will allow the Department to more easily detect operators violating the temporary abandonment or shut-in regulations.

3. Compliance

To ensure compliance with the plugging and abandonment regulations, the Department relies on a combined system of applications, permits, reports and

inspections. When an operator decides to plug a well, he must first submit a Notice of Intention to Plug and Abandon to the Department. The form requires information on both the condition of the well and the proposed method of plugging. Information must be given on the number of feet of casing in the well, casing size and weight, and the amount of casing to be left in the hole. Details must also be given about the types of plugs and filling materials, their proposed setting depths and vertical length.

Based upon a review of the information submitted, the Department may issue a permit for the proposed plugging program as submitted. Changes may be required in some proposals to ensure that subsurface fluid migration does not occur. In this case, the permit is then issued with conditions attached to it.

To allow the Department the opportunity to inspect the plugging operations, the operator must specify the date and time at which the well is to be plugged. DEC Regional Offices also require 48 hours advanced notice by mail or telephone prior to commencement of plugging operations. If the Inspector is not present at the designated time, the operator may proceed. Generally, a State inspector is on location during most or all of the plugging procedure. The inspector monitors the type, quantity and quality of materials used and has authority to require additional procedures he or she thinks necessary to ensure a sound plugging job. Site restoration is also inspected shortly after the completion of the abandonment operations to ensure compliance with regulations.

In an emergency or where compliance with the notification procedure set forth in the regulations will cause undue hardship, the owner may verbally notify the Department of his intention to plug and abandon; and the Department will acknowledge the notification verbally. The prescribed forms must then be sent in as promptly as reasonably possible and the Department will furnish a

plugging permit.

The owner or operator of an oil, gas or solution mining well must immediately notify the Department office that issued the plugging permit of any non-routine incident. Such incidents include sustained gas or fluid flows and lost circulation zones which occur during plugging or replugging operations that may affect the health, safety, welfare or property of any person. The Department requires the owner and operator to record data that may be of subsequent use for adequate evaluation of a non-routine incident.

Within 30 days after plugging a well, the owner or operator is required to file a signed Plugging Report with the Department. Complete details of the plugging and abandonment operation must be given, including verification that: (1) equipment and debris have been removed, (2) the pits and excavations have been filled (3) the casing has been cut below plow depth where appropriate and (4) the well site has been restored.

As a measure to help ensure that wells are properly plugged and abandoned, the Department may, if necessary, enter, take temporary possession of, plug or replug, and abandon any deserted idle well whenever the owner neglects or refuses to comply with any of the provisions of the regulations. The Department's plugging and abandoning or replugging and abandoning is at the owner's expense; and the owner must hold harmless the State for all accounts, damages, costs, and judgements arising from the plugging and abandoning of the well.

a. Temporary Abandonment - Site inspections are also performed prior to authorizing legal temporary abandonment status for a well. In addition, the well's casing and cementing records are reviewed and partial well site restoration is required before temporary abandonment status is granted. These steps are taken to ensure that the well is mechanically sound

and will pose no threat during the temporary abandonment period.

b. Shut In Wells - Current regulations only address the temporary shut-in of wells capable of being produced on a commercial basis. **It is recommended that the temporary shut-in regulations be amended to include all wells regardless of commercial potential.**

F. SUGGESTED FUTURE PLUGGING REGULATIONS

The effectiveness of a cement plug in preventing fluid migration is influenced by: 1) the condition of the mud or drilling fluid in the hole; 2) the volume of water used in mixing the cement and the type of cement and; 3) the technique used for placing the plug. Unfortunately, it is common for cement plugs to not set properly because of contamination by mud or gas while the cement is wet. The most common problem affecting cement plug integrity is the quantity of water used to make up the cement slurry. Excess mix water and the incorporation and infiltration of mud or other substances in the cement affects setting properties, and can result in a cement plug which lacks integrity. Gas migrating up through the plug while it is wet can also create a path for future fluid migration after the plug is set. Dehydration, or normal water loss by the cement as it sets can result in micro-annular channels.

**Therefore, it is recommended that the plugging requirements for wells be amended. The Notice of Intention to Plug and Abandon must be submitted to the Department with the complete proposed abandonment procedure. The proposed abandonment procedure will be reviewed before a permit is issued. Special conditions above and beyond the following proposed regulatory requirements may be required by the Department should special circumstances warrant it.**

**In areas where the environment will not be further compromised (Compelling justification, e.g. old oil field areas where hundreds of wells are located on which there are no records), an operator may petition for an**

**exception to the proposed plugging and abandonment requirements. For an exception to be granted, it would have to be demonstrated that no existing residence or freshwater aquifers would be impacted.**

Because downhole conditions are different in the shallow depleted sands (i.e., formations with extremely low pressure and fluid content) of the old oilfields and in the deeper gas and Bass Island formations, different abandonment requirements are proposed. In addition, the operator is given several options for proper abandonment of a well. Many of these options will allow cement plugs of shorter length if the operator will guarantee the location of the plug by tagging the plug location for a DEC witness. Shorter plug lengths and other abandonment options are proposed for the old oil field areas in order to allow these wells to be abandoned with the equipment such as dump bailers and A-frame hoists that these operators currently use. It is hoped more wells will be plugged under these requirements than if the plugging requirements necessitated the use of a larger rig and service companies which could require large expenditures for access roads that might cost more than the actual well plugging costs. **The DEC may require that the location and/or hardness of any plug be checked by re-entering the well and tagging it.** Plugs of primary concern to the DEC are the critical producing zone plug and the freshwater protection or surface casing shoe plug.

1. Old Oil Field Abandonment Requirements

Some of the old oil field areas have good potable water, others do not. Most of the wells in the old oil fields have open hole completions. Many of these wells were drilled with cable tools and most have uncemented surface casing which was installed not only to protect freshwater zones but to allow cable tool drilling to continue. It is very difficult to make drilling progress in a fluid filled wellbore with a cable tool drilling rig because the

percussion action of the chisel bit is dampened when it hits water. So in the old oil field areas where most of the wells were drilled with cable tools, surface casing set below the deepest water zone is not necessarily a good indicator of the location of the deepest potable water zone. Fortunately there is only one water zone or aquifer in most of the old oil field areas, and almost all of the water zones in this area of the state have direct continuity to surface infiltration. But where multiple zones exist, they usually have varying degrees of potability. The deeper water zones are usually more mineralized and may be unsuitable for domestic use. Behind uncemented surface casing, these zones can commingle with more potable shallow zones. For this reason, it is proposed that an attempt be required to pull uncemented surface casing or plug the annulus by ripping or perforating a minimum of two joints and placing cement across this interval.

Some of the areas which had high levels of activity and pollution have been cleansed over time because of the flushing action of the very high rainfall and groundwater recharge rate in New York State. Under the new proposed plugging requirements, water quality in the old oil field areas should improve with time.

a. Production Zone Plugging Requirements - In a typical old oil field producing well with an open hole completion, three primary options for plugging the production zone are available:

Option 1: Place cement through the production zone.

Option 2: Place sand and/or gravel through the production zone.

Option 3: Place an impermeable sealing bridge plug above the production zone.

Regardless of the option selected, a cement plug must be placed above the production zone. Whether or not a plug location tag is required, will depend on the plug length.

- If the calculated cement plug length is at least 50 feet, no tag of the plug location will be required.

- If the calculated cement plug length is the minimum of 25 feet, a tag of the plug location will be required.

b. Injection Zone Plugging Requirements - Most waterflood injection wells in the old oilfields are completed with tubing on a flood packer which has 20 to 50 feet of cement on top. The plugging requirements for injection wells shall be the same as for producing wells except with regard to sealing the injection zone. There are two options available for plugging these wells which are detailed below:

Option 1: This option is required for wells in which the USEPA has jurisdiction. Set a plug (blind packer) in the injection tubing at packer depth, sever the injection tubing above the original cement and remove. Place a cement plug in the wellbore from the severed tubing to 50 feet above, with a calculated excess for tubing infill.

Option 2: This option can be used when EPA does not have jurisdiction (e.g. old injection wells which have not been active since 1982). Set a plug (blind packer) in the injection tubing at packer depth. Place a minimum of 25 feet of cement inside the injection tubing with a macaroni string. Sever the injection tubing and remove. Place a minimum of 25 feet of cement in the wellbore above.

c. Abandonment Fluid Requirements - If the operator can verify that the interval between the producing zone and the surface casing shoe has no brackish water or Devonian shallow gas zones, the requirement of an abandonment fluid can be waived. Verification will consist of drilling log

records, electric or other geophysical log interpretation, fluid level monitoring, Division of Water studies and/or other geologic reports on the field area.

If this interval is not dry, the hole shall be filled with a gelled fluid or water as specified in the permit issued by the Regional Minerals Manager. Minimum requirements for the gelled fluid are a density of 8.65 ppg (pounds per gallon).

d. Uncemented Surface Casing Plugging Requirements - If an old oil well has tacked or uncemented surface casing, an attempt must be made to pull the surface pipe unless the operator submits documentation for a variance. A supporting bridge plug or impermeable sealing packer should be placed 25 feet below the shoe of the surface casing prior to any attempt to remove the casing. If all of the surface casing is recovered, a 50 foot plug across the former surface casing seat shall be placed. The plug location must be tagged after an appropriate WOC time unless it is placed on an impermeable sealing packer which has been weight tested prior to the cement plug placement. Testing will consist of setting down a weight with the tubing that is equivalent to the calculated weight of the cement plug.

All water bearing and/or fluid loss zones between the shoe plug and surface shall be sealed with cement and any remaining open hole intervals shall be filled with gel or as specified in the permit.

In the old oil fields, the minimum length of the cement surface plug shall be 15 feet.

e. Plugging Requirements for Uncemented Surface Casing Recovery Failure - When attempts to pull uncemented surface casing have been only partially successful, the operator is given several options for properly sealing the surface casing stub. After placing 50 feet of cement across the surface casing shoe as detailed previously, the operator has the following

options:

Option 1: Place cement from the top of the casing shoe plug to a minimum of 25 feet above the casing stub with a calculated cement excess for any annular fill-up.

Option 2: Fill the casing stub with gel or water as specified and set a cement plug inside the casing a minimum of 25 feet below the stub to 25 feet above with a calculated excess for annular fill-up.

Option 3: Spot the gel in casing stub as specified and set a 25 foot cement plug in the open hole above the stub or set a 25 foot cement plug on a supporting bridge plug or impermeable sealing packer. Place a minimum of 25 feet of cement on top of the plug.

After plugging the surface casing stub, any water bearing or fluid loss zones in the remainder of the hole must be sealed with cement, and all inter-plug intervals filled with gel. **A minimum of 15 feet of cement is required at the surface in all old oil wells.**

If uncemented surface casing cannot be recovered, proper abandonment of this portion of the hole will be as follows:

1. Place a minimum of 50 feet of cement across the surface casing shoe.
2. Determine the depth of unbonded pipe and perforate or rip a minimum of two joints of casing immediately above the depth of unbonded pipe or the shoe plug whichever is lower, or
3. perforate above the depth of unbonded pipe, and attempt to establish circulation and squeeze cement into the surface casing - hole annulus.
4. If there are cement returns to the surface, spot gel into the casing and place the surface plug.
5. If the casing wellbore annulus is so tight as to prohibit the

establishment of circulation and cement returns to the surface or the equipment, casing condition and/or wellhead configuration prohibit the attempt, two options are available:

Option 1: Place cement from the casing shoe plug to 25 feet above the ripped or perforated joints. Appropriate WOC time and a tag of the plug location is required. The remaining interval must be filled with gel and a 15 foot surface plug placed.

Option 2: Plug the entire wellbore from the shoe plug to the surface with cement.

f. Cemented Surface Casing Plugging Requirements - If an old oil well has cemented surface casing, the proper plugging requirements will be as follows:

1. Place a cement plug from 25 feet below the surface casing shoe to 25 feet above. A tag of the plug location will be required unless it is set on a previously weight tested packer.
2. Fill the remaining interval with gel or as specified in the permit, and place a 15 foot surface plug.

2. Gas Well Plugging Requirements

Most gas wells in New York are deeper and are completed differently than oil wells in the shallow Devonian sands. Title 6, Chapter 5, Subchapter B, Part 554.4, requires that if production casing is run, it shall be cemented by a pump and plug or displacement method with sufficient cement to circulate above the top of the completion zone to a height sufficient to prevent any movement of oil, gas or other fluids around the exterior of the production casing. Thus, gas wells usually have cemented surface casing and partially cemented production casing. Wells completed in a Primary or Principal Aquifer

where the State requires both casing strings be cemented to the surface are an exception.

For proper abandonment, the entire perforated zone or producing interval should be plugged with cement in a well with partially cemented casing. The current practice of allowing a bridge plug capped with cement at the top of the producing zone can be fallible in a cased hole where the top and/or quality of the cement behind the casing is unknown. Under certain conditions, fluids from the former producing zone could still migrate up the wellbore - casing annulus if the original cement job on the production casing was inadequate. The placement of cement across the producing zone will decrease the chances of this occurring because the weight of the column of cement across the zone will push some cement through the perforations into the production zone. Under special circumstances, a bridge plug capped with cement at the top of the zone will be allowed, such as when the production interval is a fracture or lost circulation zone known to take fluids. Other circumstances warranting exception will be reviewed on an individual basis. Because of their greater depth, gas wells are usually plugged through tubing by the balance method. With this method, as cement slurry is displaced through tubing into a fluid filled hole, a certain amount of mixing occurs. Most operators use a calculated excess to compensate for cement lost to mixing when they plug by this method. This is another reason why greater plug lengths are recommended for gas wells.

a. Production Zone Plugging Requirements - For the typical Medina gas well completed with partially cemented production pipe, the following options for properly sealing the production zone are available:

Option 1: Set a cement retainer above the perforated zone and squeeze the volume of cement calculated to fill the hole below. Place

50 feet of cement on top of the retainer (no plug location tag required).

Option 2: Place cement from T.D. across the producing zone to 50 feet above the top perforation (plug location tag may be required).

Option 3: (Available only when the production zone is a lost circulation zone or other special circumstances). Set a cast iron bridge plug or other sealing packer above the producing zone, and cap with 50 feet of cement (no plug location tag required).

b. Uncemented Production Casing Plugging Requirements - As part of the plugging process, operators are required to rip or perforate any uncemented casing left in the hole, and squeeze cement through the openings into the open annular space. However, it is difficult to make certain that the cement is completely distributed in the annular space, and that this conduit is fully plugged. Therefore, it is recommended that an attempt be made to recover uncemented production casing below the shoe of the surface casing.

When the surface casing is cemented below the deepest potable water, and no hydrocarbon or significant brackish water zones occur behind uncemented pipe, casing recovery will be at the operator's discretion, but as stated previously, it is strongly recommended that uncemented casing be pulled. The following options are suggested for properly plugging a well with uncemented production casing.

Option 1: Recover casing above the determined depth of unbonded pipe. Place a cement plug of 50 feet across the stub, 25 feet below and 25 feet above, with a calculated excess for annular fill up.

Option 2: Recover production casing no higher than 25 feet below the surface casing shoe. Place cement from 25 feet below the stub

to 50 feet above the surface casing shoe with a calculated excess for annular fill-up.

Option 3: If the uncemented casing is not recovered, it must be perforated at least 50 feet below the shoe of the surface casing, circulation established, and sufficient cement squeezed to fill the annulus. One hundred feet of cement must also be placed inside the pipe across the surface casing shoe.

c. Plugging Requirements for Hydrocarbon or Signficant Brackish Water Zones Behind Uncemented Casing - Current regulations, Part 555.5, sections 1 and 2, require that wells be capped or plugged in such a manner as will prevent the migration of fluids. In addition, the regulations require that the wellbore be filled with cement from total depth to a minimum of 15 feet above the top of the shallowest formation that has produced hydrocarbons in the vicinity, or alternatively, each hydrocarbon zone be plugged by the placement above each zone of a cement topped bridge plug.

In essence, the above sections require that all formations containing hydrocarbons or fluid with sufficient volume and pressure to migrate be sealed. A zone behind uncemented pipe will not be properly sealed by the placement of cement inside the casing alone. Thus, revision of the current regulations is necessary. The following options are recommended for properly plugging a zone behind uncemented casing.

Option 1: Perforate the production pipe below the annulus producing zone, and squeeze sufficient cement into the annulus to cement above the zone. Place a cement plug within the casing across the annulus producing zone to 50 feet above.

Option 2: Recover the casing below the annulus zone and plug with cement from 25 feet below the stub to 50 feet above the annulus

producing zone.

For hydrocarbon and brackish water zones in open hole, the following pluging options are recommended:

Option 1: Place cement from total depth to 50 feet above the shallowest hydrocarbon/brackish water zone.

Option 2: Plug across each hydrocarbon/brackish water zone to 50 feet above each zone with cement. Spot gel in all inter-plug intervals.

d. Junk-in-the-Hole Plugging Requirements - "Junk-in-the-hole" is a generic term which defines any debris, obstruction, or lost equipment existing in a well. "Junk-in-the-hole" poses a signficant problem when it is located above the producing formation in a well. Remediation techniques are employed to retrieve or displace the junk and restore access to the producing zone. When these measures fail and the well is rendered unproducible, the wellbore must be plugged and abandoned.

To ensure adequate plugging of the well when the producing zone is isolated below "junk-in-the-hole", alternate plugging procedures must be followed. It is recommended that the operator be required to set a cement retainer (a cement retention packer) above the junk and attempt to squeeze sufficient cement to fill the hole volume from total depth to the top of the junk. An additional 50 feet of cement is to then be placed on top of the cement retainer.

e. Plugging Requirements for a Well with Uncemented Production and Surface Casing - A wellbore cannot be properly sealed with cemented pipe inside uncemented casing or two strings of uncemented pipe in place. Therefore, an effort must be made to recover the production pipe below the shoe of the surface casing, including milling out the pipe. After the production pipe is removed, procedures to properly plug uncemented surface

casing and to protect the freshwater intervals will follow those given for uncemented surface casing in old oil wells except for the plug lengths. A 100 ft. surface casing shoe plug, 50 ft. in and 50 ft. out, and a 50 ft. surface plug will be required.

f. Plugging Requirements for a Well with Cemented Production and Surface Casing - Completing a well with both the surface and production casing cemented to the surface may cost an additional $1,500 to $3,000, but the well will be much easier and cheaper to properly abandon. After the producing zone and any hydrocarbon or significant brackish water zone above the producing zone have been plugged, and the wellbore filled with an approved fluid, a 100 foot plug placed inside the production string across the surface casing shoe is recommended as an additional freshwater protection measure.

g. Surface Plugging Requirements - **It is recommended that the minimum length of the surface plug in gas wells be extended from 15 feet to 50 feet.**

3. Application to Other Wells Regulated by the Division of Mineral Resources

**The recommended plugging requirements apply not only to oil and gas wells but also to injection disposal wells, solution mining, geothermal, and stratigraphic test wells with modifications as appropriate.**

## G. SUMMARY OF THE PROPOSED REGULATORY REQUIREMENTS

### 1. General Abandonment Requirements

**Cement plugs shall be placed in wells across all oil, gas and fluid zones, across all casing stubs, below the base of the freshwater zone or across the surface casing shoe, and at the ground surface. Intervals between plugs shall be filled with a heavy mud or other approved fluid.**

2. Hole Fluid

a) Intervals not occupied by cement shall be filled with an approved fluid as specified by Regional Minerals Manager. Gelled fluid minimum requirements are density equal to 8.65 ppg with a 10 minute gel-shear strength of 15.3 to 23.5 ibs/100 sq. feet.

b) Abandonment fluid requirement can be waived in the shallow Devonian oil fields by Regional Manager if the operator submits documentation which verifies that the interval between producing zone and surface casing shoe is void of even minor fluid or hydrocarbon zones.

3. Oil and Gas Zone Plugs

a. Oil Wells - Place either cement or sand/gravel through production zone or set in impermeable sealing bridge plug above the zone. An additional 50 feet of cement shall be set above with no tag required or place 25 feet of cement and tag.

b. Gas Wells - (1) Squeeze cement producing zone through cement retainer set above perforations or place cement from T.D. across producing zone. (2) Cap with an additional 50 feet of cement. (3) For a lost circulation zone or other special circumstances, a cast iron bridge plug/sealing packer shall be set above the producing zone and capped with 50 feet of cement. Tagging of these plugs may be required.

4. Injection Zone Plugs

a) A blind packer shall be set in the injection tubing at flood packer depth.

b) USEPA jurisdiction. (1) Sever injection tubing above original cement and remove. (2) Cement shall be placed in the wellbore 50 feet above point of tubing severence, including excess for tubing infill.

c) Non-USEPA jurisdiction option. (1) Place 25 feet of cement in tubing. (2) Sever tubing and remove. (3) Place 25 feet of cement in wellbore above.

5. Other Oil and Gas Zones

All zones containing hydrocarbons or fluid must be sealed with cement.

a. Zones in Open Hole - Place cement plugs across each zone to 50 feet above and spot gel in all inter-plug intervals or place cement from T.D. to 50 feet above shallowest zone.

b. Zones Behind Uncemented Casing - Recover casing below the zone and place cement from 25 feet below the casing stub to 50 feet above the zone or perforate and squeeze the zone and place cement within the casing across the zone to 50 feet above.

6. Junk-in-the-Hole

When the producing zone is isolated below the junk, a cement retainer shall be set above the junk and sufficient cement shall be squeezed to seal the producing zone below. An additional 50 feet of cement shall then be placed atop the retainer.

7. Surface Casing Shoe Plugs

a. Uncemented Casing - (1) Oil Wells. Cement plug shall be 50 feet across the casing shoe or the former casing seat. This plug shall be set on top of a supporting bridge plug or impermeable sealing packer. (2) Gas Wells. A 100 foot cement plug across the shoe shall be placed.

b. Cemented Casing - (1) Oil Wells. A 50 foot cement plug shall be placed across casing shoe and shall be tagged if not set on a weight tested packer. (2) Gas Wells. A 100 foot cement plug shall be placed across casing shoe.

8. Casing Recovery

Unless the operator has documented the need or advisability for a variance, a conscientious attempt shall be made to recover uncemented casing. If uncemented casing cannot be recovered, it must be perforated or ripped and

have cement squeezed or placed into the annular space or filled to surface with cement.

a. Surface Casing - Partial Recovery - (1) The surface casing stub shall be sealed with 50 feet of cement, 25 feet in and 25 feet out or shall be capped with a sealing bridge plug/packer with 25 feet of cement on top. (2) Excess cement shall be used to account for annular fill-up and all water bearing or fluid loss zones above the stub shall be sealed with cement. All inter-plug intervals shall be filled with an approved fluid.

b. Surface Casing - No Recovery - Surface pipe shall be ripped or perforated and fluid shall be circulated through the annulus. (1) If circulation can be established, cement shall be squeezed into the surface casing annulus. (2) When squeezing cannot be accomplished due to annular restrictions casing condition or the wellhead configuration, either the entire wellbore from the shoe plug to the surface shall be filled with cement or cement shall be placed from the surface casing shoe plug to 25 feet above the ripped or perforated joints, and a tag of this plug shall be required.

c. Production Casing with Cemented Surface Pipe - Uncemented production casing shall be recovered no higher than 25 feet below the surface casing shoe or perforated below the surface casing shoe and sufficient cement squeezed to fill the annulus. If the casing is recovered, a 50 foot cement plug shall be placed across the stub, 25 feet in and 25 feet out. As with all stub plugs, excess cement shall be placed to account for annular fill-up.

d. Production Casing with Uncemented Surface Casing - Every effort shall be made to recover the production casing below the shoe of uncemented surface casing, including milling out the pipe. Gas wells with uncemented surface casing shall be plugged according to procedures outlined in 4(a)(b) with the exception that a 100 foot cement plug across the former surface casing shoe will be required.

**9. Surface Plugs**

**Minimum cement plug lengths shall be as follows:**

**a) Oil Wells - 15 feet.**

**b) Gas Wells - 50 feet.**

## H. SUMMARY OF ENVIRONMENTAL IMPACTS OF PLUGGING AND ABANDONMENT OPERATIONS

The plugging and abandonment of oil and gas wells is critical to environmental protection and no negative long term environmental impacts result when proper plugging and abandonment procedures are followed.

Deficiencies in the accepted well plugging practices of previous decades have caused serious localized oil, gas and/or brine pollution in some areas of New York State. Oil in underground sources of drinking water, with its carcinogenic components and long term residence in ground water, has the potential to cause negative impacts.

Vegetation and ground disturbances are the primary short term impacts associated with plugging and abandonment operations. These may occur when equipment is moved on site and the site is restored. Depending on the well location, short term minor surface and ground water turbidity and siltation are possible but not likely impacts. The long term impacts resulting from plugging activities are beneficial.

The plugging and abandonment requirements in the Department's existing regulatory program have improved the protection of ground and surface waters, but there are deficiencies in the existing regulations that could, in certain well plugging situations, allow environmental problems. Adoption of the recommended more stringent plugging requirements will eliminate these deficiencies while giving oil and gas operators plugging options tailored to wells of different type and construction. Figures 11.3 through 11.12 show the proposed plugging requirements with the options given for different wells and plugging situations.

# FIGURE 11.3

## PLUGGED OIL WELL WITH AN OPEN HOLE COMPLETION AND TACKED SURFACE CASING: ALL CASING RECOVERED

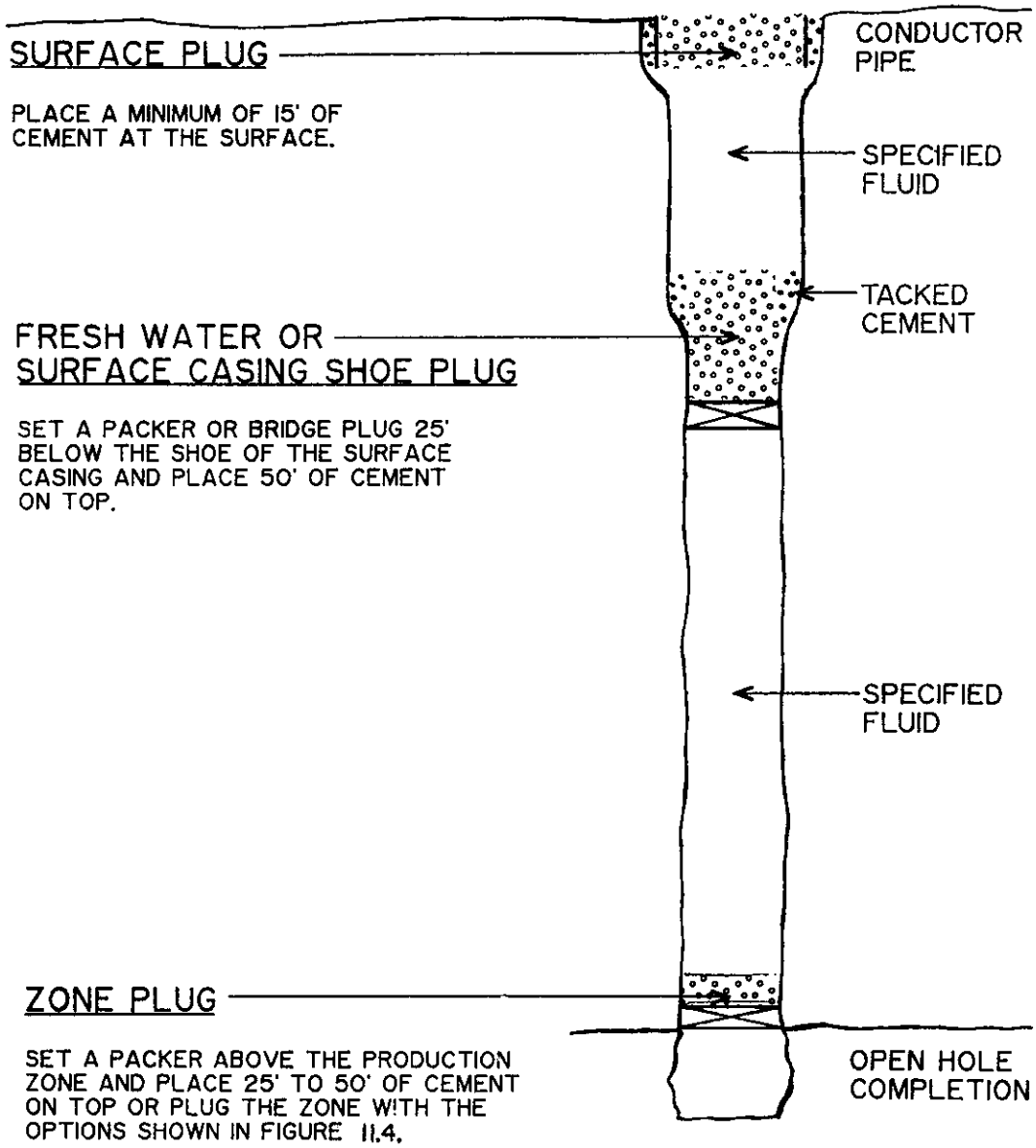



**FIGURE 11.3**

# FIGURE 11.4

## PLUGGED OIL WELL WITH AN OPEN HOLE COMPLETION AND TACKED SURFACE CASING: PART OF THE SURFACE CASING LEFT IN THE HOLE

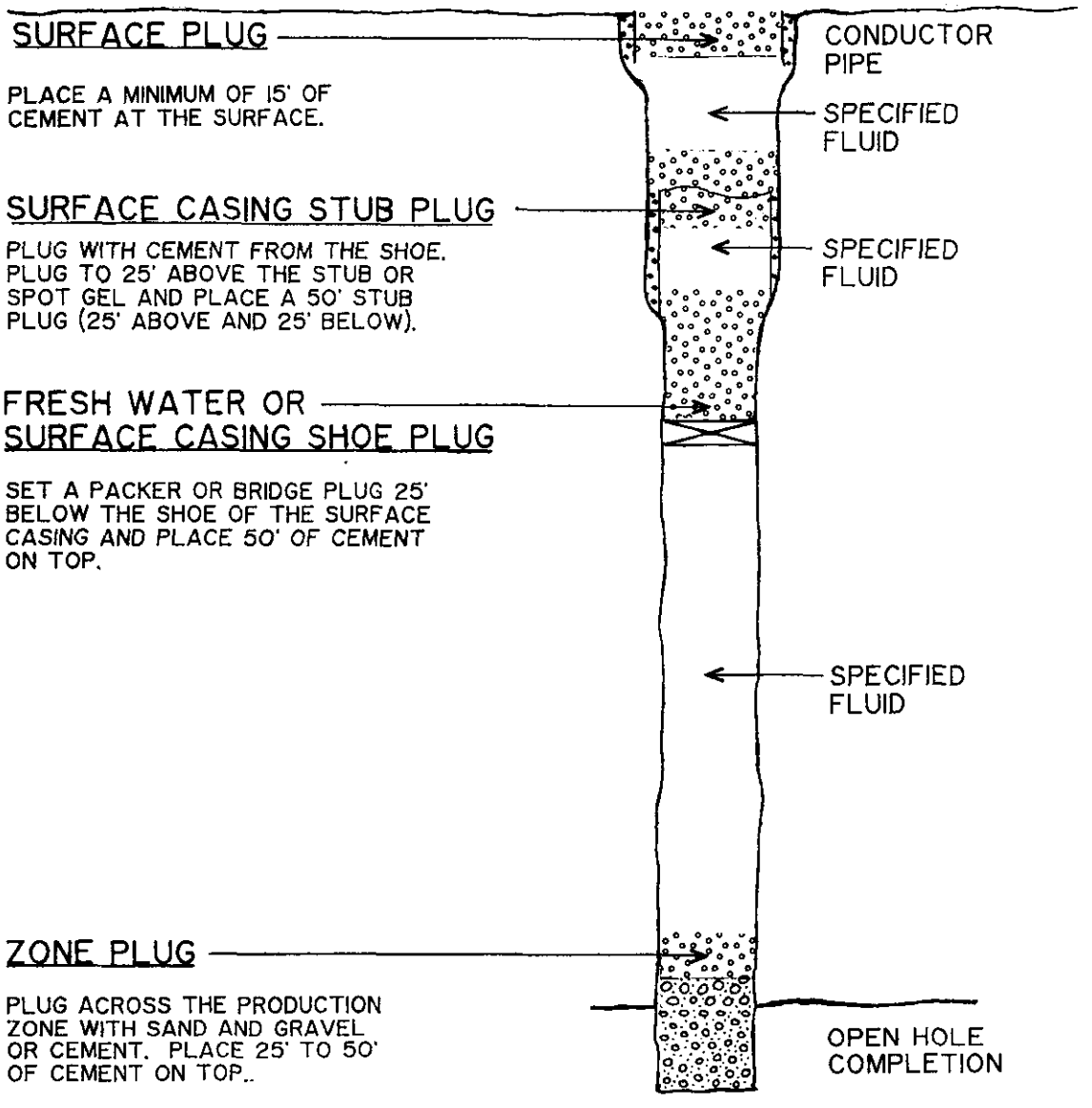



**FIGURE 11.4**

# FIGURE 11.5

## PLUGGED OIL WELL WITH AN OPEN HOLE COMPLETION AND PARTIALLY OR TOTALLY UNCEMENTED SURFACE CASING: ALL SURFACE CASING LEFT IN THE HOLE

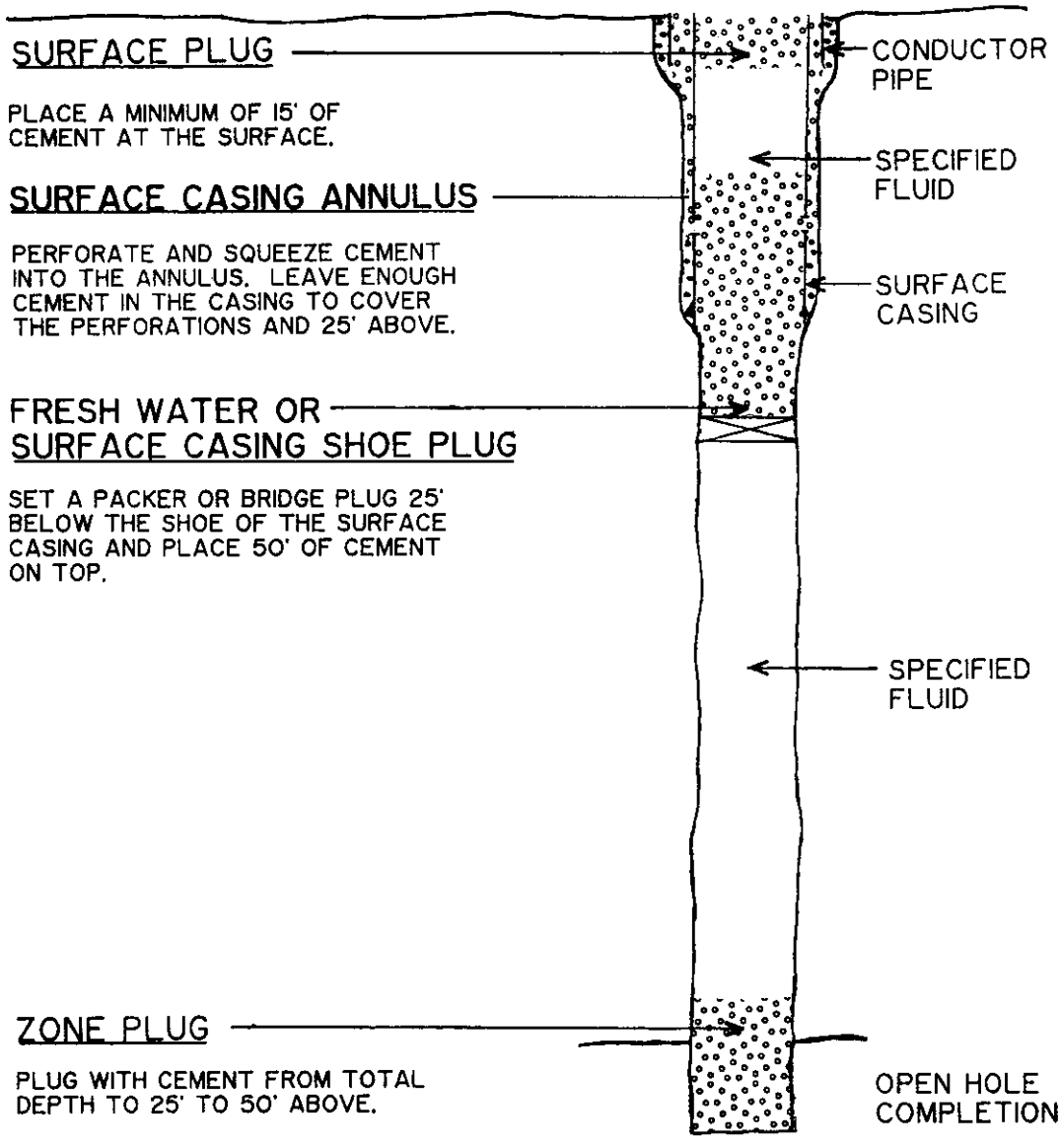



**FIGURE 11.5**

# FIGURE 11.6

## PLUGGED INJECTION WELL WITH AN OPEN HOLE COMPLETION AND TACKED SURFACE CASING: UNABLE TO RECOVER SURFACE CASING OR SQUEEZE

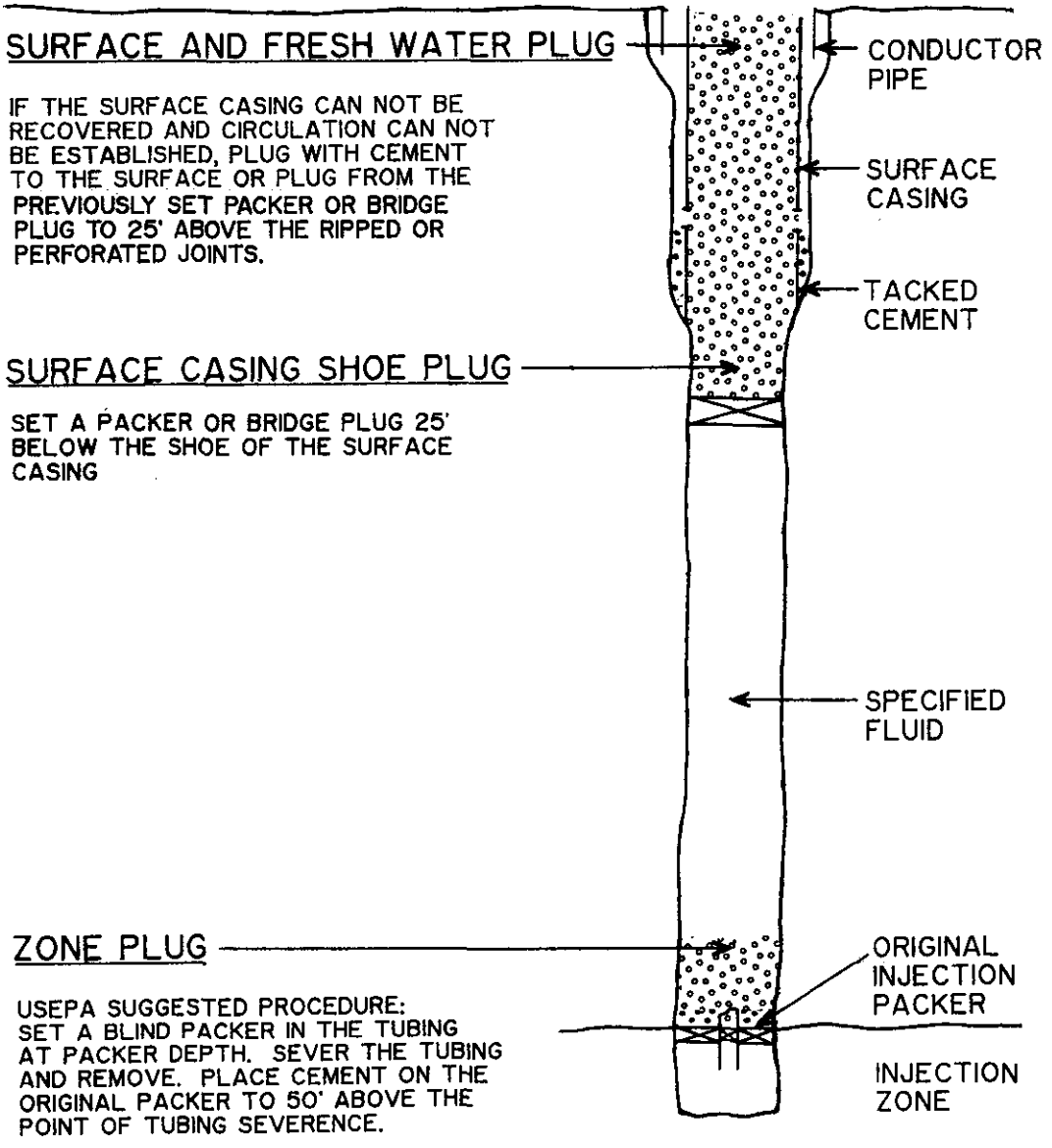



FIGURE 11.6

# FIGURE 11.7

**PLUGGED INJECTION WELL WITH AN OPEN HOLE COMPLETION AND TACKED SURFACE CASING : PART OF THE SURFACE CASING LEFT IN THE HOLE**

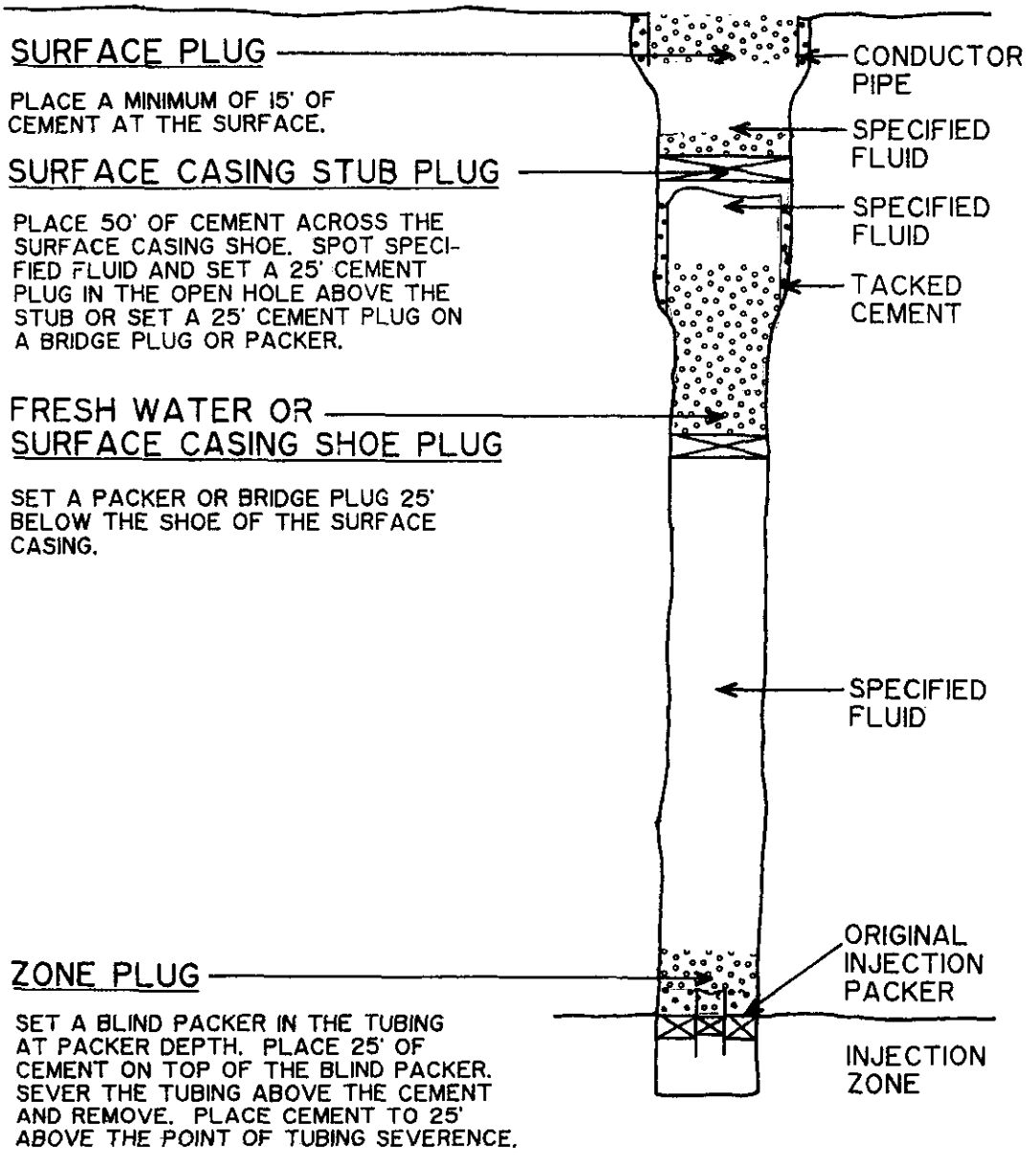



**FIGURE 11.7**

# FIGURE 11.8

PLUGGED GAS WELL WITH A LOST CIRCULATION ZONE AND PARTIALLY CEMENTED PRODUCTION CASING: COMBINATION STUB PLUG AND SURFACE CASING SHOE PLUG

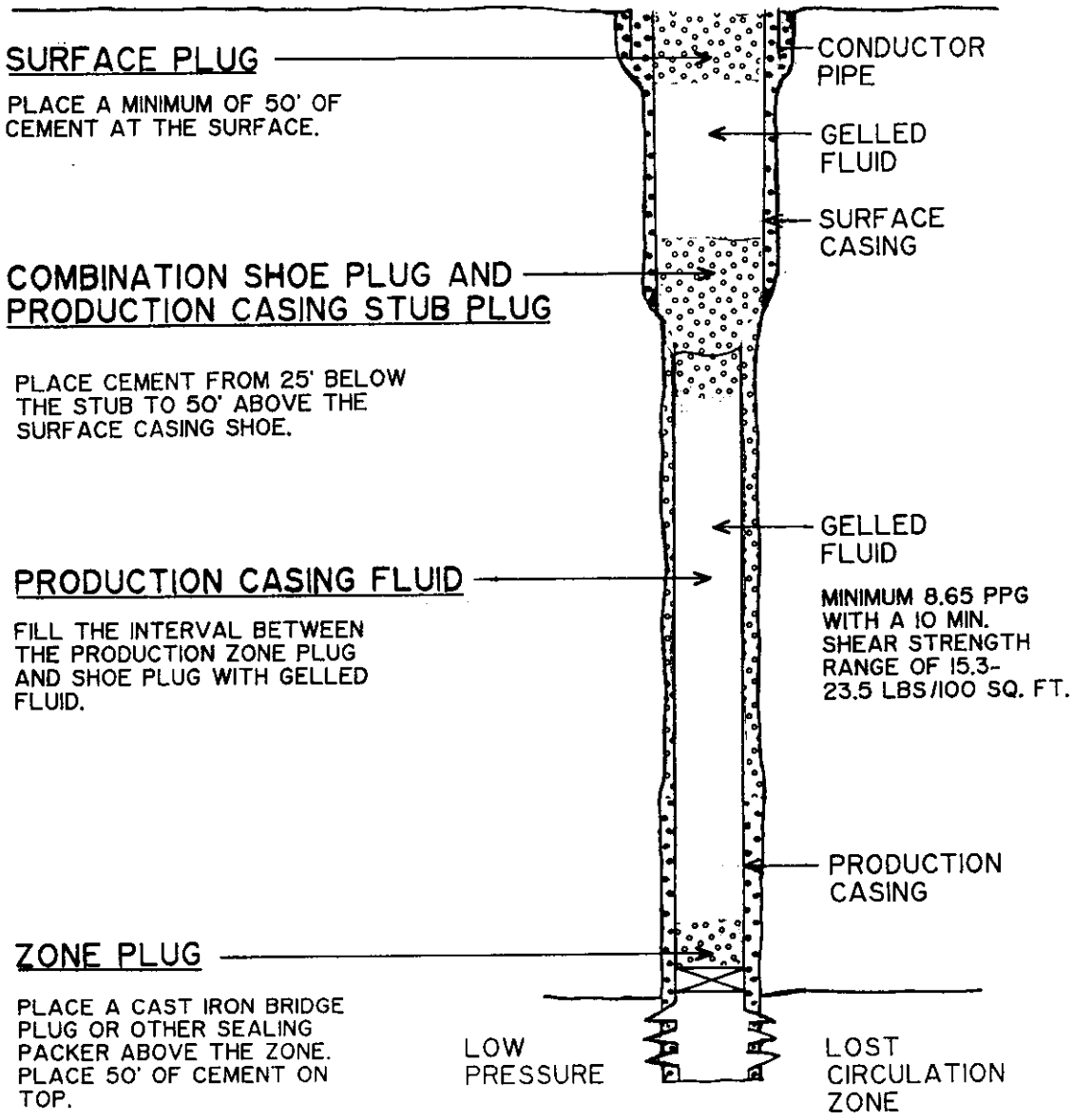



**FIGURE 11.8**

# FIGURE 11.9

**PLUGGED DUAL COMPLETION WELL WITH THE PRODUCTION CASING RECOVERED FAR BELOW THE SHOE OF THE SURFACE CASING: SURFACE CASING CEMENTED TO THE SURFACE**

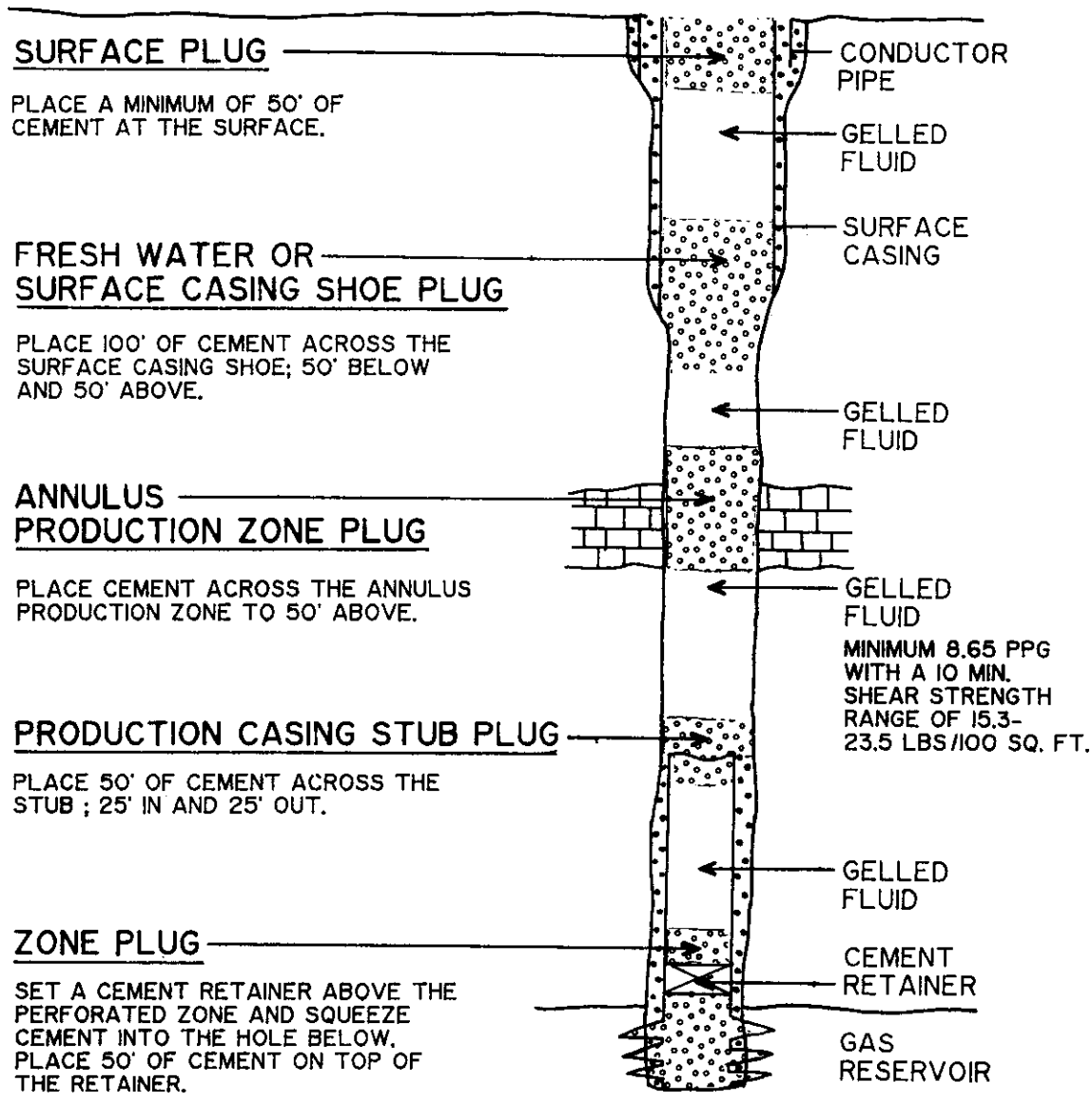



**FIGURE 11.9**

# FIGURE 11.10

## PLUGGED GAS WELL WITH PARTIALLY CEMENTED PRODUCTION CASING: ALL CASING LEFT IN THE HOLE

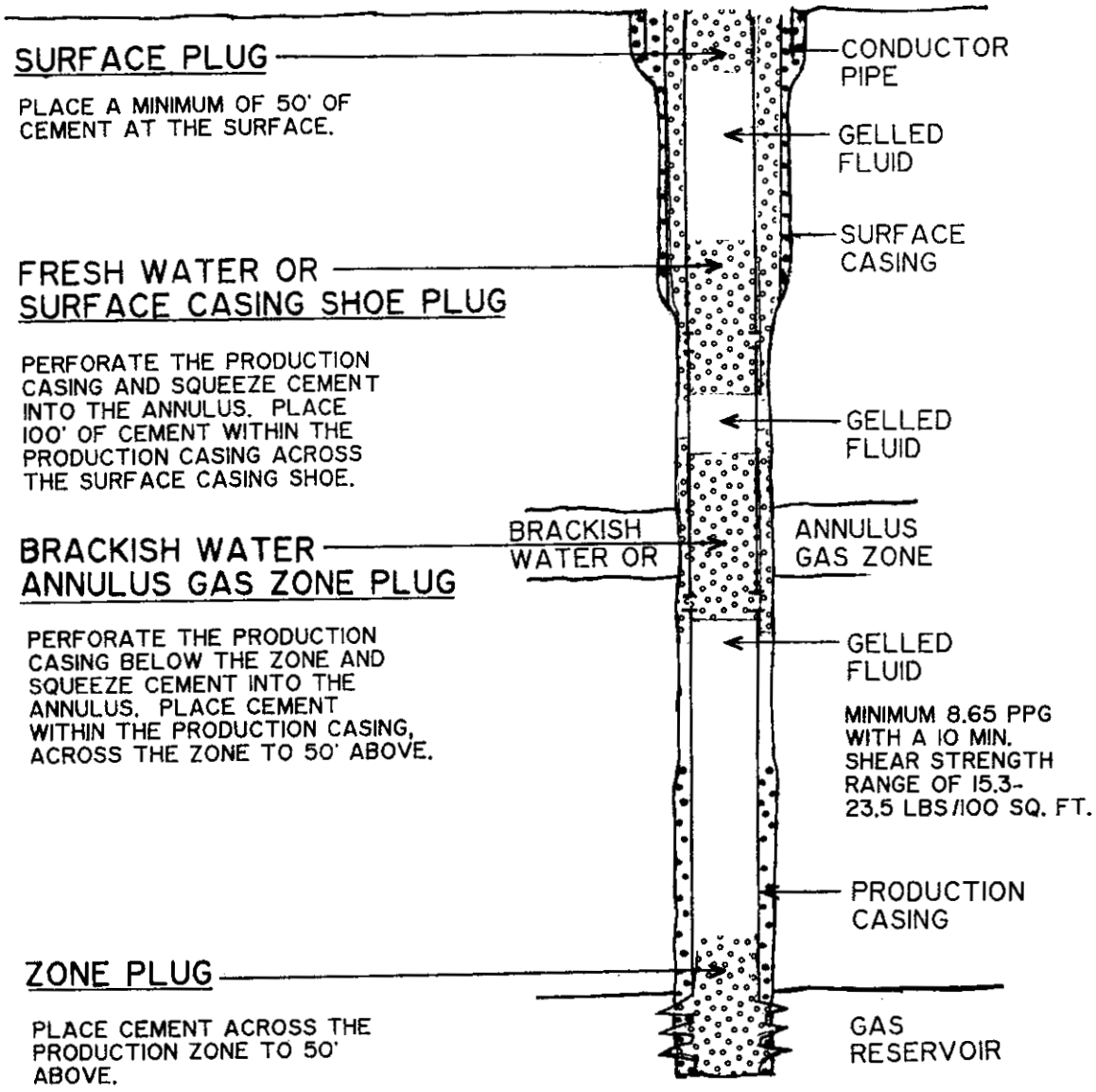



FIGURE 11.10

# FIGURE 11.11

## PLUGGED GAS WELL WITH JUNK IN THE HOLE

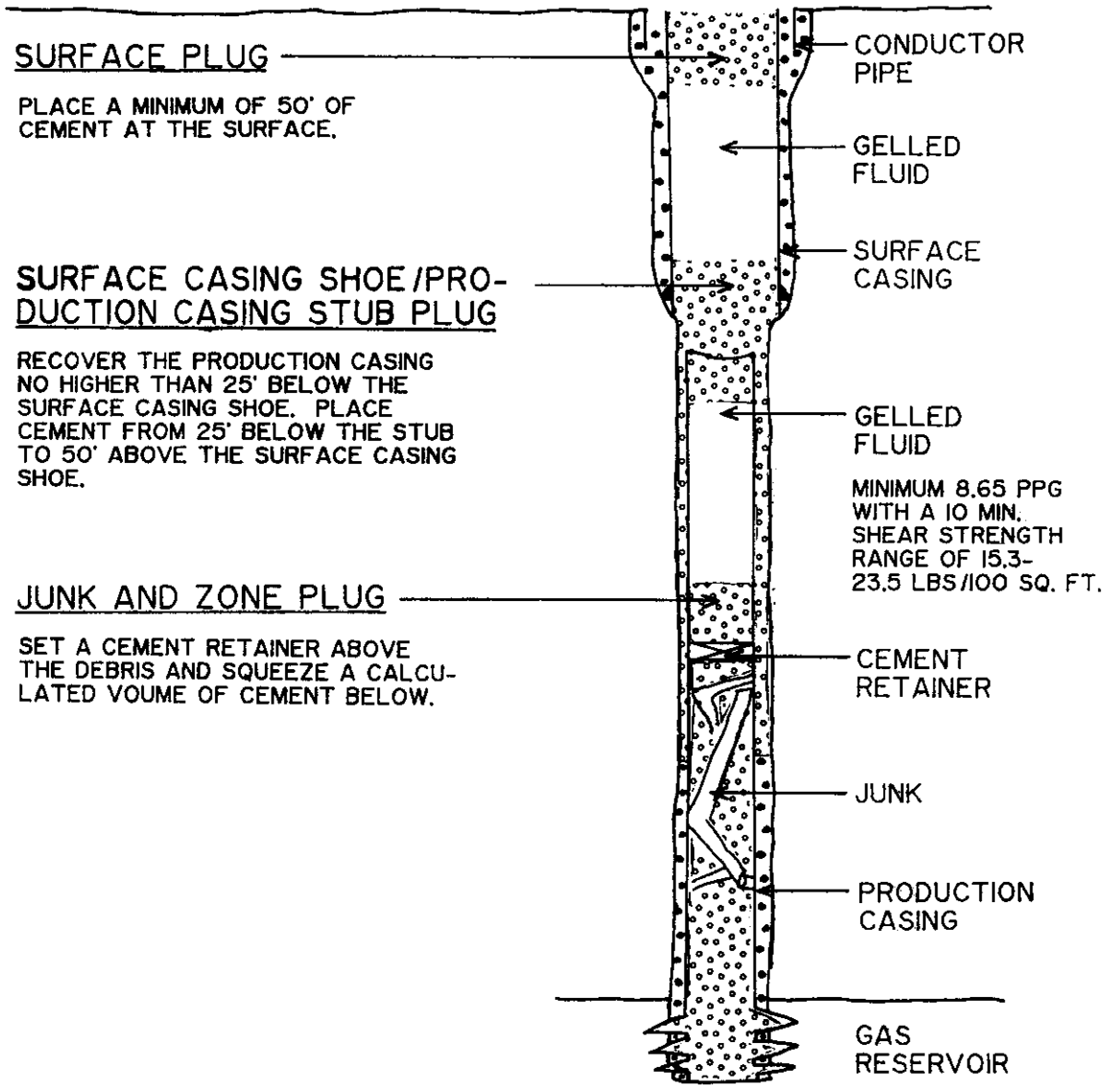



**FIGURE 11.11**

# FIGURE 11.12

## DRY HOLE GAS WELL WITH BRACKISH WATER AND UPPER NON-COMMERCIAL GAS ZONE

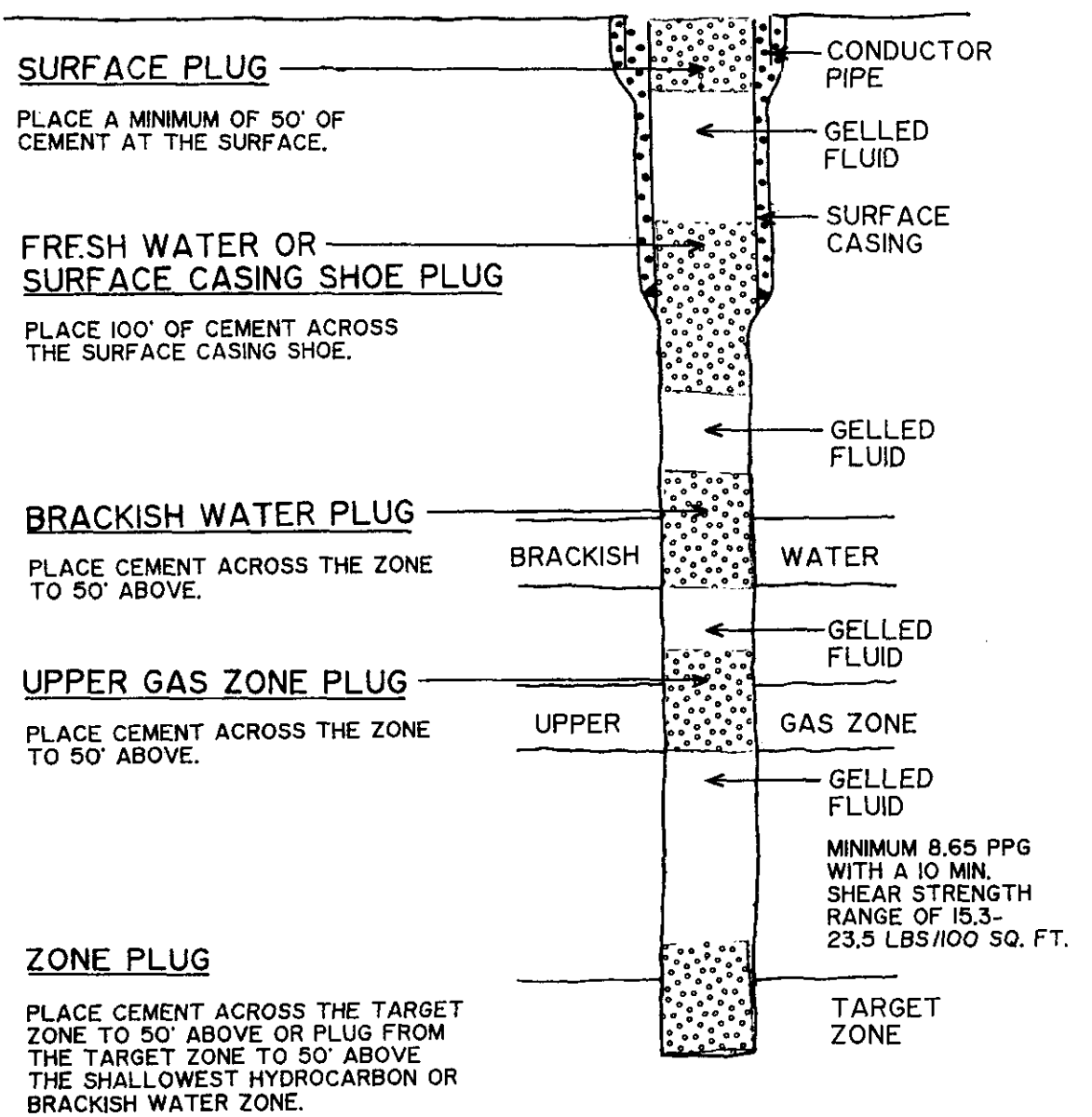



**FIGURE 11.12**