FUNDAMENTALS OF SALT DOME VALUE

Cost elements are necessary considerations in market and income analyses, even of raw salt land.

by Russell J. Avant, CRE

Is it acceptable to study a problem for 12 years and still have questions about it? In 1978, I was asked to give counsel on the proper division of an expropriation (condemnation) award on West Hackberry Salt Dome in Louisiana. The division was to be made between the mineral interest and the surface interest in 20-acres. The question was not the value, but the ratio of the division. The award already had been tendered and was considered to be acceptable, and it was being negotiated for the division of interest. However, because of the condemnation (expropriation) by the U.S. Department of Energy (DOE) for the Strategic Petroleum Reserve (SPR); some inkling had to be made of the value of the salt dome land.

In the process of determining the division, the question of dome value was raised. Arriving at the answer to that question appeared to be formidable and seemed to involve an analysis of every phase of the oil/petrochemical industry. However, formal attempts to value salt domes apparently had begun only a few years earlier, with the advent of the SPR program.

Each of several encounters with salt dome problems since 1978 has revealed more about dome value. This writing is a distillation of my experience with salt domes from 1978 through 1989. Most of the research involves the Big Hill Salt Dome taking for the DOE. But I still have questions.

Big Hill Salt Dome

The SPR program chose Big Hill Salt Dome for its final reserve site. A taking was declared in December 1982, with DOE offering $45,000 an acre. The dome is near Port Arthur, Tex., and at that time, it was owned mostly by Amoco Production Co. Amoco thought the dome was worth more than $45,000. This was understandable since in 1979, the company had sold 100-acres of the dome for $100,000 an acre.

My role as one of two counselors was to evaluate the offer, recommend a counteroffer and a range within which to negotiate. I and the other counselor were to work independently but we were to pool the data gathered. Our data shopping list included uses of caverns, sales, rents, national and local pipeline maps, books, studies, existing and proposed caverns, growth of caverns, operating statements of caverns, production and pricing of oil, petrochemicals, gas, liquid petroleum gas (LPG), demand, transportation, geology, etc. etc...

The DOE provided geological studies on the subject project. And Amoco had lots of information, of course, on dome geology, production, refining, petrochemicals, pipelines, storage, shipping, marketing and cavern construction and operation, much of

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which was available to us. However, in order to obtain sensitive information, we needed to agree to confidentiality; death was the penalty if any of this information were to be revealed within 5 years! The accumulated documents eventually grew to weigh over 100 pounds. Just reading and organizing them took a bit of time.

In the management of the study, I retained a chemical engineer to answer questions, make cost estimates, collect storage rents and advise on technical petroleum matters. Fenix and Scisson, Inc., a mining and engineering firm was hired to advise on cavern development. Their man, Al Medley, had encyclopedic knowledge of mining, geology and salt domes. He had worked on many cavern projects and seemed to know every storage operation. He had written several papers for his professional society and furnished these as well as other studies.

The data search, including interviews with principals, brokers, experts and operators, took much time. The subject was complex, and close study had to be given to each aspect. Sales figures, for instance, had to be checked with several sources. After the interviews, the writeups were checked by the interviewees. In several cases, significant differences were found in data obtained from different sources; significant differences also were found between later interpretations of facts and information as it was first understood.

The counseling problem involved the collection of masses of hard-to-earn data. After months of processing this data, however, general conclusions did emerge. Defining fundamental concepts in advance helped the search, the processing and the explanation of the data. This article is background which, hopefully, may give direction to those who are organizing a counseling study.

Salt Storage Background

Dome storage is involved with the production, processing, refining, transportation and marketing phases of the oil/petrochemical industry.

Salt cavern storage is a new technology which has become an integral part of this industry. Although other uses of salt cavern storage are developing, oil/petrochemical industry uses dominate.

The following paragraphs are offered as background on salt domes, their geology, characteristics and uses and their importance to industry.

Geology

The geology of domes is amazing. Think of it, a salt bed runs 30,000 feet down into the ground. The salt bed is lighter than the soil that covers it. Under pressure, it becomes a slow moving liquid which extrudes in columns to the surface, like a thick oil rising through water. The tops of the columns are what we know as salt domes. There are hundreds along the Gulf Coast, but domes are found in other places as well. The domes usually are associated with oil production, and the shallow ones are useful for storage.

Salt Characteristics

Salt has intrinsic value for many uses. It is an essential commodity for human consumption and as a preservative. It is in industrial demand as a source of sodium and chlorine for refrigeration, deicing highways and other uses. At one time, salt was scarce and was used as money. This is no longer the case as bedded or dome salt has been found in quantities measured in cubic miles.

The highest uses of salt land are for brining, mining and storage. The best use of many salt domes is for underground storage. This is owing to the characteristics of salt. These are:

- water solubility, which permits low-cost solution mining.
- high strength, which permits large caverns and pressure containment.
- plasticity, which permits the equalization of stresses through broad ranges of pressure and enables self-healing of fractures that arise from excessive pressure.
- non-reactivity, which means salt is insoluble in hydrocarbons and does not chemically react with many materials.

Development Of Salt Storage Technology

Mining of salt has been done for centuries, but solution mining is recent. The earliest solution mining proposal found on record is in a patent issued to George Smith in 1880.

The use of salt domes for storage is more recent. It began in the United States in the early 1950s. Although R.L. Pattison applied for a patent in 1945, the patent was not granted until 1952, and it was assigned to Sid W. Richardson in 1954. The first recorded use of a salt cavity for storage was by D.C. Stewart in Hutchinson County, Kansas, in 1948 for storing propane; the second was in Winkler County, Texas, in 1950.

Salt land may be used to store solids, such as hazardous wastes for isolation from the environment, liquids and gases, including compressed air for power reserve. Storage of hydrocarbons and large volumes of pressurized liquids and gases is the most common use. Employment of this technology likely will expand. Future uses should include the storage of compressed air for power generation, hazardous wastes, natural gas and other materials.

Growth Of Dome Storage

The use of salt domes for storage has grown steadily since 1950. According to the Gas Processors Association, the cavern capacity in the United States has grown from 106 million barrels in 1965 to 521 million in 1982; this is a compounding annual growth of 9.81%. In 1981 and 1982, U.S. salt cavern capacity increased 16.85%, for a rate of 8.43% a year. Over half (52.6%) of the storage is in Texas, next is Louisiana with 19.29% and Kansas with 14.82%.

Because it has a large concentration of refineries and petrochemical plants combined with many shallow salt domes, Texas has accounted for 85.93% of the growth of salt caverns in the United States.

For 1981 and 1982, storage in Texas increased from 208 million to 274 million barrels, a 66 million barrel increase. This is 31.84% for two years, or 15.92% a year. Continuing at that same rate of increase, Texas should see an additional 44-million-barrel-a-year demand from industry. Considering that the Sabine Pass Terminal had initial plans for storing 15 million barrels at Big Hill, the SPR program alone should exceed this growth rate.

The Economics Of Salt Storage

There are several advantages to salt storage which will provide some understanding of the reasons for its growth. These are:

- The cost of construction. Costs for developing a salt storage facility can be much less than the cost of building any other type of storage facility, depending on the volume, design requirements and proximity to the storer's needs.
- The nature of the cavern. A salt cavern is a pressure container; so large volumes of material can be stored at pressures that may not be feasible to obtain or maintain in other methods of storage. Mined caverns also maintain constant humidity.
- The protection they afford. Environmental problems associated with the storage of hazardous materials can be reduced. Exposure of stored materials to natural and man-designed hazards such as war also are much reduced.
- The longevity. Salt caverns have indefinite lifespans if they are properly maintained.

There are, however, three problems that need to be solved. Salt storage requires a water supply and a brine disposal method, metering in and out rather than more accurate tank gauge metering and a drying process when withdrawing certain products. Salt domes also may not be within practical reach of those who need them, and they may not be practical for small volume storage.

The Distance Question

The underlying economics of salt storage are realized mainly in the lower costs of their construction and maintenance and their ability to hold pressure. The cost of the container is not the full picture, however. The distance between the salt storage facility and those who need it is a major value question, because pipeline runs are needed to bridge that distance and costs depend on their length, size and the terrain they cover. Thus, one of the comparative measures of domes is the difference in cost of pipelines connecting the users.

The needs for storage are normally found at one or more of the following:

- pipeline corridors that serve markets and production centers
- refineries and petrochemical plants
- shipping channels

The question arises as to what is a practical distance. When distances from the users were checked for 20 storage operations in Texas and Louisiana, they ranged from 1 to 70 miles, with an average of 23.5 miles and a mode at 18 to 25 miles.

Cost Comparisons

The cost comparisons in Table 1 show why the demand for salt cavern storage has been growing. For pressure storage, the cost difference is dramatic and justifies long runs of pipes. Also for pressure storage, the cost of surface cryogenic or pressure storage is so high that it is often considered to be impractical. Until the development of salt cavern storage, most LPG was flared.

TABLE 1

Relative Costs of Storage Containers (1982—1983)

Volume (in barrels)	Salt Dome Caverns (Cost/ Barrel)	Pressure Tanks (Cost/ Barrel)	Oil Tanks (Cost/ Barrel)
100,000	$10.00	$40 to $120	$6.92
200,000	5.00	40 to 120	5.52
400,000	2.50	40 to 120	4.23
500,000	2.01	40 to 120	4.09
1,000,000	1.22	40 to 120	4.09
2,000,000	.57	40 to 120	4.09
3,000,000	.42	40 to 120	4.09

Note: These costs do not include pipelines to the site, brine injection wells or a brine pit. Injection into the cap rock is very low cost: deep well disposal is between $700,000 and $1 million.
The costs include a one-mile, eight-inch pipeline to the injection well for a one-well cavern. The costs can vary upward if fast leaching, fast rate of product withdrawal, operating brine needs and other factors are included.

Products that do not require pressure containment, such as crude oil, fuel oil, gasoline and others, can be stored at low cost in volumes exceeding 200,000 barrels. Crude is usually refined as it arrives, and it requires storage only of surge needs. Natural gas, fuel oil, LPG and gasoline, however, have seasonal demands and require large-volume, off-season storage.

Industry has not been interested in speculative storage. Apparently, only the federal government needs to provide an emergency supply of oil in case of an oil embargo. The SPR program proposes a reserve that would exceed the industry total.

The SPR cost for storage is higher than the costs that are common to industry. The reason is the higher rate of recovery that is required. SPR requires two wells for each cavern, a high rate of water supply, brine disposal and large pipelines. The Louisiana Offshore Oil Port (LOOP), for example, has five wells per cavern to handle the high-volume delivery and recovery requirements.

Incompatible Uses

The delicate aspect of cavern development is running the pipe string into the cavern. Where sulphur mining has been done in the cap rock, subsidence is expected, and it can rupture the pipe string.

If the integrity of a pipe string is lost, any commodity that has been stored under pressure may be lost. Contamination of the environment is a potential liability. For these reasons, the development of domes that have increased risks is avoided, and threatened caverns usually are abandoned if loss of the stored products would cost more than the creation or maintenance of the cavern.

Uninformed Sellers

Market value is the highest price the property will bring under four conditions:

1. Buyer and seller are free of undue stimulus.
2. Both parties are well-informed, and each is acting prudently in his own best interest.
3. A reasonable time is allotted to test the market.
4. Payment is made in cash or its equivalent, or third-party financing is available.

Many industry land purchases do not meet all of these conditions, particularly the condition that requires both parties to be well-informed.

This condition may be met when an industry buys a farm on which it plans to build a plant. There may be miles of farmland that would qualify as an equal substitute for any site. Even though farmers have no knowledge of the value of industrial land, they compete for the sale with their knowledge of the farm market.

With salt domes, however, scarcity is a major factor. Substitution of equal property is not accomplished easily, and the best use of the property probably involves more than farming. Knowledge of the supporting economics of salt dome property usually lies only with members of the industry.

To be informed, a seller should know the significance of the:

- depth of the salt
- quality of the salt
- proximity of the dome to
  - pipelines
  - deep water channels
  - refineries and chemical plants
  - markets
- mineral production in cap rock
- proven quality of domes
- water source and brine disposal locations
- cost of alternative methods of storage
- rental value and underlying economics of the caverns
- market comparables and competitive offerings
- identifying the buyer

These items of information usually are beyond the ken of farmers or most other owners of a dome. In small areas that have a long history of competitive demand, however, evidence has been found that a few non-industry sellers do become knowledgeable.

That some sales do not meet the definition of market value is believed to be true on the basis of (1) the fact that prices for some salt domes are so much lower than prices for other salt land; this implies a lack of knowledge of supporting economics; and (2) the knowledge of the circumstances surrounding some of these sales.

Examples include Barbers Hill, where recent sales and rejected offers to purchase ranged from \$137,500 to \$272,000 an acre; and Big Hill which sold for \$100,000 an acre in 1979. These prices contrast sharply with early sales on Barbers Hill, one sale on Moss Bluff Dome, one sale on North Dayton Dome and one sale on West Hackberry Dome, and they appear to be the result of the lack of knowledge of the sellers. One sale on West Hackberry Dome for \$3,429 an acre did, however, involve undue stimulus. This became apparent when the price of the dome was compared to the rental costs of \$65,000 an acre in a lease between Olin and others members of the family in their settlement with the SPR shortly after this sale.

Oil/Chemical Industry Land Economics

Oil industry affairs are technical and complicated, and persons outside of the industry seldom have a grasp of the technology or the economics of oil or chemical plants.

When the best use of dome land is for salt cavern storage, the oil/petrochemical industry demand predominates. This predominance is due mainly from growth of LPG use in petrochemicals and fuels. LPG comes from oil and gas production and from refining. Until dome storage was developed, most LPG was flared. Knowledgeable people advise that much of the petrochemical industry is viable only because of dome storage.

Capital Requirements

The capital requirements for refineries and chemical plants are large. Plant costs may range from hundreds of millions to billions of dollars. Such numbers are nearly incomprehensible until they are reduced to the unit cost of production. A refinery with 500,000 barrels a day throughput may cost \$1 billion. The cost can be expressed in a comprehensible number as \$2,000 a barrel of capacity.

The capital outlays for refineries and chemical plants are so large that the cost of a site is often a fraction of a decimal point. In the Sabine Triangle, the site value is usually less than 1%; yet 1% is less than the range of accuracy of estimating the cost of the plant.

For example, an Olefin plant recently was constructed on 100-acres. Prior to construction, the cost was estimated to be \$300 million. It was understood that the cost on completion of the plant was closer to \$400 million. The value of the site from comparable sales would have approximated \$10,000 an acre and totaled approximately \$1 million, only ¼ of 1% of the cost of the plant.

Even at 1% of \$400 million, or \$40,000 an acre, the land value still would not have been significant. This is more than any 100-acre tract has sold for in the Sabine Triangle, with one exception. This is 100-acres of the Big Hill Dome, which were sold at \$100,000 an acre. On the more active Barbers Hill Dome, cash offers by major corporations of \$200,000 and \$272,000 an acre have been rejected by the owners.

The value of industrial land usually is set by the prices that would be paid for more frequently occurring lesser uses. This does not mean the sites are unimportant but that the land is available at such prices. When industry locates in farming areas, it pays farm prices; when it locates in residential areas, it pays residential prices, and so on. Industry pays only enough to displace developers of other land uses. It does not pay more because more is not asked, because substitutions can be made easily and because sellers are not well-informed about the industrial values of their sites.

Questions of the availability and cost of transportation, fuels, water, feedstocks, labor, markets, politics and other factors relegate the cost of land to minor importance in the consideration of plant location.

If for some reason the land is not available in the best location, then higher costs or the loss of efficiency can be extreme in relation to typical land values. If land is scarce, however, the prices of land will rise to the point of acquisition.

The only places that industrial land values tend to approach economic limits is when land is scarce. This occurs when industry competes with industry or with a developer of an equally high use of land. In the Sabine Triangle, the only times industry competes with industry are: (1) along the ship channels and (2) on the salt domes. Even so, sales sometimes reflect little, if any, of the supportable industrial value.

The general conclusions that can be drawn from an analysis of oil/chemical industry land economics are:

1. Storage is an essential and integral part of the oil/petrochemical industry.
2. Salt caverns offer the lowest cost and greatest safety for storage of large volumes of liquids and gases.
3. Land cost is seldom a significant part of the investment that is required for oil and petrochemical plants. Land prices usually are set by other, lower uses.
4. Land values push economic limits only when land is scarce and industry competes with industry.
5. Grantors are seldom fully informed about the economic value of their land to industry except in areas of intense competition.

Units Of Comparison

The land value of salt domes can be compared on the basis of distance factors, storage per acre and tract size.

Distance Factors

The cost of storage is not simply the cost of the cavern but the total cost of the storage system. The need for storage stems from plants, transmission pipelines to markets and from production centers and shipping terminals.

The distance between a dome and a plant, a transmission pipeline and a terminal affects the value of land in an inverse relationship to pipeline costs. An apt analogy is a bucket of money that is budgeted to purchase a storage facility: the more paid out to the construction of pipelines, the less that can be paid for land. This is a simplified, working principle. More money left by reason of low pipeline cost accrues to land value. Insufficient amounts of money left by reason of high pipeline costs requires an alternative to be sought.

Within an area of 45 miles, salt dome storage seems to be a winning method. To relate sales and other data to the subject, it is necessary to develop reasonable estimates of (1) the most frequent number of barrels needed per acre; (2) the usual tract size for storage projects; and (3) the usual need for pipelines in terms of size and number.

Storage Per Acre

As to the number of barrels stored per acre, examples can be found ranging from 50,000 to around 600,000 barrels per acre. The physical capability of most salt domes is over 1 million barrels per acre.

For light hydrocarbon storage, however, the practical sizes of caverns allow storage of 1 million to 3 million barrels. With spacing, this means 200,000 to 400,000 barrels per acre or 300,000 barrels of light hydrocarbons stored per acre on the average.

Larger caverns have lower storage costs per barrel than smaller caverns; however, there is a practical size limit due to the need to separate stored products. Multiple caverns, therefore, are the norm, with more land put into spacing. Enlargement of caverns is low in cost and easy to accomplish. Caverns are enlarged simply by using fresh water instead of brine for removing products, and this can be done as spacing permits. Washing to permit communication between one cavern and another means that two caverns become one and only one product can be stored thereafter.

Examples of large numbers of barrels stored per acre are found often. On Barbers Hill, the Xral facility stored 20 million barrels on 45-acres, or 444,000 barrels per acre. At Big Hill, the SPR plans to store 140 million barrels on 254-acres for a rate of 550,000 barrels per acre. The intensity is higher at the LOOP in Clovelly, Louisiana. However, a relatively common intensity for light hydrocarbon storage is around 300,000 barrels per acre. Thus, 300,000 barrels per acre should be an acceptable norm to consider when converting the costs, rents and value per barrel to the value per acre.

Typical Tract Size

In projecting typical site and pipeline needs, a standard 100-acres is used as mid-range. This is the size of a tract that was bought recently for one project. Most comparable sales have been related to all three storage system needs, i.e., pipelines corridors, plants and ship channels. Typical pipeline requirements also must be selected in counseling on domes.

Summary

The norms used to relate costs, rents and values to land for 1982 were as follows:

- Intensity of storage was 300,000 barrels per acre.
- Site size was 100-acres more or less.
- Pipelines were needed for 100-acres of storage development: two 12-inch lines were needed to connect the dome with the industry center; one 15-inch and one 20-inch line were needed to connect with the pipeline corridor; two 24-inch lines were needed to connect with the shipping channel.

These norms vary by time and location, but they were deemed to be reasonable for the 1981 to 1985 period in the area from Houston to the Sabine Triangle, which includes Port Arthur, Beaumont and Orange, Texas, on the Gulf Coast.

As a result of the analysis of the data from which these fundamental concepts were drawn, it was recommended that the offer of $45,000 per acre should not be accepted. Ultimately, the settlement was over twice the initial offer.