Proposed Version

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Manual for Discounting Oil and Gas Income

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Introduction

The Texas oil and gas industry is an important and significant contributor to the diversity of the state's economy, providing jobs at all levels and investment in exploration, production and refining. Petroleum is a principal driver of the Texas economy. The Texas Railroad Commission (RRC) is the primary state agency responsible for permitting, monitoring and regulating aspects of the industry.

In 1993, the Texas Legislature enacted Tax Code Section 23.175. It requires the Comptroller's office to develop and distribute to each appraisal district an appraisal manual specifying the methods and procedures to calculate the present value of oil and gas properties using discounted future income.[1]

In 2011, the Texas Legislature required the Comptroller's office to specify the formula used to limit the price applied in the second through the sixth years of an appraisal. It also revised the formula used when calculating the price adjustment factor in 2015.[2] [3]

This manual explains discounting, the discounted cash flow (DCF) equation, DCF appraisal and three acceptable techniques for estimating a discount rate in the DCF method, which include market surveys, oil and gas sales analysis and weighted average cost of capital (WACC), also called band of investment.

Appraisal districts must use the methods, procedures and formulas specified in this manual, which is adopted by Comptroller Rule 9.4031.[4]

1 Tex. Tax Code §23.175
2 Tex. Tax Code §23.175(b)
3 Tex. Tax Code §23.175(a)
4 Tex. Tax Code §23.175(c)

Proposed Version

History of Oil and Gas in Texas

The earliest discoveries of oil and gas formations in Texas happened in the late 19th century. On Sept. 12, 1866, Lyne Taliaferro Barret drilled the first oil-producing well at Melrose in Nacogdoches County at 106 feet. The first well-equipped refinery in Texas was built in Corsicana in 1898 and shipped its first production in 1899.[5]

On Jan. 10, 1901, Capt. A.F. Lucas discovered a salt dome of oil and produced a "gusher" at Spindletop, near Beaumont.[6] In 1908, the Goose Creek Field was the first offshore discovery, located in Galveston Bay 21 miles southeast of Houston. A gusher in 1916 created a boom that reached a peak annual production of 8,923,635 barrels by 1918 with onshore and offshore wells.[7] **Exhibit 1** lists other significant oil and gas discoveries in Texas. [8]

Major Oil and Gas Formations

Texas has some of the largest oil and gas formations in the US, including the Permian Basin, East Texas Field, Barnett Shale, Eagle Ford Shale, Granite Wash and Haynesville/Bossier.

Permian Basin

The first well drilled in the Permian Basin was in Mitchell county in 1921. The Permian Basin is approximately 250 miles by 300 miles, stretching to southern New Mexico, with more than 7,000 fields in West Texas. Well depths range from a few hundred feet to five miles deep. This area provides almost 40 percent of U.S. domestic crude oil and 15 percent of natural gas, according to the Federal Reserve Bank of Dallas.[9]

EXHIBIT 1

Oil and Gas Discovery	County	Year
Electra Field	Wichita	1911
Damon Mound	Brazoria	1915
Barbers Hill	Chambers	1916
Ranger Field	Eastland	1917
Burkburnett Townsite Field	Wichita	1918
Blue Ridge	Fort Bend	1919
Mexia	Limestone	1920
Panhandle	Hutchinson	1921
Luling Field	Caldwell	1922
Howard-Glasscock Field	Howard	1925
Hendricks	Winkler	1926
Raccoon Bend	Austin	1927
Sugar Land	Fort Bend	1928
Darst Creek Field	Guadalupe	1929
Van	Van Zandt	1929
Pettus	Bee	1929

East Texas

The East Texas field in Rusk County was discovered by wildcatter C.M. Joiner in October 1930. It is still active and has produced more than 5.2 billion barrels of oil. The field covers more than 140,000 acres in Gregg, Rusk, Upshur, Smith and Cherokee counties in the northeastern part of Texas, with well depths primarily below 3,500 feet. The East Texas field created overproduction and prices quickly dropped. To enforce production restrictions, Governor Ross S. Sterling declared martial law on Aug. 17, 1931 and sent the National Guard to shut down the entire field. The Legislature enacted

5 Texas State Historical Association, 2018, *"History of Oil Discoveries In Texas"*, https://texasalmanac.com/topics/business/history-oil-discoveries-texas (last visited Feb. 3, 2021).

6 Robert Wooster, "Lucas, Anthony Francis," *Handbook of Texas Online*, https://www.tshaonline.org/handbook/entries/lucas-anthony-francis (last visited Feb. 03, 2021).

7 Priscilla Myers Benham, *"Goose Creek Oilfield"*, Handbook of Texas Online, https://www.tshaonline.org/handbook/entries/goose-creek-oilfield (last visited Feb. 3, 2021).

8 Texas State Historical Association, 2018, *"History of Oil Discoveries In Texas"*, https://texasalmanac.com/topics/business/history-oil-discoveries-texas (last visited Feb. 3, 2021).

9 Railroad Commission of Texas, *"Permian Basin,"* https://www.rrc.state.tx.us/oil-and-gas/major-oil-and-gas-formations/permian-basin/ (last visited Feb. 3, 2021).

legal proration to regulate how much oil could be produced. This system of regulation is still utilized today.[10]

Barnett Shale

During a mapping exercise in the early 20th century, geologists noted thick, black, organic-rich shale in a rock outcropping close to a stream. The Barnett Shale consists of sedimentary rocks near 8,000 feet. It was named for John W. Barnett who settled in San Saba County during the late 19th century. It is one of the largest onshore natural U.S. gas fields, covering an estimated 5,000 square miles, extending from Dallas to the west and south.[11]

The Barnett Shale is where George Mitchell first successfully implemented hydraulic fracturing ("fracking") technology to unlock shale gas in 1997.[12]

Eagle Ford Shale

The Eagle Ford Shale is a band roughly 50 miles wide and 400 miles long with an average thickness of 250 feet that extends across Texas from the Mexico border into East Texas. It is up to 70 percent carbonate and produces more oil than other traditional shale plays. It also produces natural gas. Fracking is beneficial in producing gas from the brittle, carbonate-rich shale rock. Most of the current production is between 4,000 and 14,000 feet below sea level. It is the source rock for the Austin Chalk and the East Texas Field.[13]

Granite Wash

The Granite Wash produces both oil and gas through a tight sand play located in the Texas Panhandle and Western Oklahoma. It is several washes of rock fragments and organic particles about 160 miles long and 30 miles wide with a depth from 11,000 to 15,400 feet. On average, the play is 3,000 feet thick.[14]

[10] Texas State Historical Association, 2018, *"History of Oil Discoveries In Texas,"* https://texasalmanac.com/topics/business/history-oil-discoveries-texas (last visited Feb. 3, 2021).

[11] Railroad Commission of Texas, *"Barnett Shale,"* https://www.rrc.state.tx.us/oil-and-gas/major-oil-and-gas-formations/barnett-shale/ (last visited Feb. 3, 2021).

[12] *The New York Times Magazine*, "The Lives They Lived: George Mitchell," https://www.nytimes.com/news/the-lives-they-lived/2013/12/21/george-mitchell/ (last visited Feb. 3, 2021).

[13] Railroad Commission of Texas, *"Eagle Ford Shale,"* https://www.rrc.state.tx.us/oil-and-gas/major-oil-and-gas-formations/eagle-ford-shale/ (last visited Feb. 3, 2021).

[14] Railroad Commission of Texas, *"Granite Wash,"* https://www.rrc.state.tx.us/oil-and-gas/major-oil-and-gas-formations/granite-wash/ (last visited Feb. 3, 2021).

Haynesville/Bossier

The Haynesville/Bossier Shale is in East Texas and Western Louisiana along the Gulf Coast. It can produce from 3 to 7 billion cubic feet of gas per well in each formation. It produces hundreds of trillions of cubic feet of gas. The shale thickness ranges from 200 to 305 feet, with depths of 10,000 to 14,000 feet.[15]

Fracking

In 1862, at the Battle of Fredericksburg, Virginia, Col. Edward A.L. Roberts observed artillery rounds exploding in a small canal that was blocking the battleground. The ensuing fractures in the canal's walls prompted him to apply explosives to oil exploration after the Civil War. It led to drillers pouring liquid nitroglycerin down well bores to perforate the casing. On March 17, 1949, fracking began about 12 miles east of Duncan, Oklahoma and Halliburton and Stanolind Co. fractured another oil well near Holliday, Texas.[16]

In 1967, the U.S. government used a 13 foot by 18-inch nuclear device to fracture a gas well in New Mexico at a depth of 4,240 feet. "The reasoning was that the relatively inexpensive energy available from nuclear explosions could prove useful for a wide variety of peaceful purposes," notes a report later prepared for the U.S. Department of Energy.[17]

In Texas during the 1980s, gas producer and geologist George Mitchell worked on refining fracking in the Barnett Shale. A mixture of water, sand and chemicals was forced down the well at high pressure to fracture the shale rock. The porous sand wedged into the cracks allowing the gas to flow. The combination of horizontal drilling and fracking in the 1990s unlocked the oil and gas hydrocarbon resources in the tight shale rock.

Environmental and health issues are a concern because fracking requires millions of gallons of water for each well. New

[15] Shale Experts, *"Haynesville-Bossier-Cotton Valley Overview,"* https://www.shaleexperts.com/plays/haynesville-bossier-cotton-valley/Overview (last visited Feb. 3, 2021).

[16] American Oil & Gas Historical Society, aoghs.org, *"Shooters – A Fracking History,"* https://aoghs.org/technology/hydraulic-fracturing, Original: Sept. 1, 2007, last updated April 20, 2020 (last visited Feb. 3, 2021).

[17] American Oil & Gas Historical Society, aoghs.org, *"Project Gasbuggy tests Nuclear Fracking,"* https://www.aoghs.org/technology/project-gasbuggy, original: Dec. 10, 2013, last updated Dec. 7, 2020 (last visited Feb. 3, 2021).

technologies and processes are being developed to reduce or eliminate water used to fracture shale rock including:

- water additives that allow for water recycling and reuse;
- foams and gels from pressurized gases (such as propane or carbon dioxide) that replace the water;
- environmentally friendly fracking fluids that use less water and chemicals;
- acoustic energy fracking, which can potentially improve the penetrating power of fracking and reduce required water and chemicals;
- microwave fracking, which uses almost no water (but requires a lot of electricity); and
- solar- and natural gas-powered equipment to replace diesel equipment and reduce poisonous pollutants and greenhouse gases.

Discounted Cash Flow

Discounted cash flow (DCF) appraisal is the most common method for valuing oil and gas property. The underlying concept of discounting future income to a present-day value applies a discount rate to the future income. Discount rate components include historic, current and future market expectations. An appraiser uses DCF method techniques such as market surveys, sales analysis and weighted average cost of capital to determine a discount rate range. The appraiser's final discount rate selection will typically fall within this discount rate range.

Appendix A provides a description of property-specific risk factors and examples to illustrate DCF appraisal, weighted average cost of capital (WACC) estimating and standard deviation analysis.

Discounting

Because investors prefer immediate cash over future cash returns, they "discount" them —paying less now for future cash flows. The discount amount depends on:

- the length of time until the cash is due;
- the level of risk that the cash will not be tendered when due; and
- the rate of return available from other comparably risky investments.

Typically, discounting converts future income to present value using annual discount factors. The discount factor declines for each successive year to reflect the reduced value of revenue received in the future. The appraiser calculates the present worth of the forecast revenue stream by multiplying the projected net income (cash flow) for each year by the calculated discount factor for that year. DCF analysis is the process of deriving discount factors from the discount rate (also known as the yield rate).

The International Association of Assessing Officers (IAAO) defines discount rate as:

> The rate of return on investment; the rate an investor requires to discount future income to its present worth. It is made up of an interest rate and an equity yield rate. Theoretical factors considered in setting a discount rate are the safe rate earned from a completely riskless investment (this rate may reflect anticipated loss of purchasing power due to inflation) and compensation for risk, lack of liquidity and investment management expenses. The discount rate is most often estimated by band-of-investment analysis or a sales comparison analysis that estimates typical internal rates of return.[18]

The discount rate is a key variable in DCF analysis, making correct rate selection crucial. The market's expectations are critical when choosing a discount rate. The Appraisal Institute's Appraisal of Real Estate states:

> "The estimation of an appropriate discount rate is critical to DCF analysis. (A yield rate is a generic term used to describe many rates. When anticipated cash flows are used, it is called a discount rate. When actual past cash flows are used, it is called an internal rate of return.) To select an appropriate discount rate, an appraiser must verify and interpret the attitudes and expectations of market participants, including buyers, sellers, advisers and brokers. Although the actual yield on an investment cannot be calculated until the investment is sold, an investor may set a target yield for the investment before or during ownership. Historical yield rates derived from comparable sales may be relevant, but they reflect past, not future, benefits in the mind of the investor and may not be reliable indicators of the current required yield. Therefore, the estimation of yield rates for discounting cash flows should focus on the prospective or forecast yield rates anticipated by typical buyers and sellers of comparable investments. An appraiser can verify

[18] International Association of Assessing Officers, *Property Appraisal and Assessment Administration*, (1990) Pp. 641-642.

investor expectations by interviewing the parties to comparable sales transactions or reviewing marketing materials for comparable properties recently offered for sale."[19]

Discounted Cash Flow (DCF) Appraisal

The DCF method is versatile and widely used to appraise income-producing property. An appraiser using DCF projects an anticipated net income for each year of the property's remaining economic life; discounts each annual cash flow to present value; then adds all the present values to obtain the total market value of the real property interest being appraised. **Exhibit 2** shows the DCF equation, including the variable definitions.

EXHIBIT 2

DCF Equation PV = CF1 × (PWF1) + CF2 × (PWF2) + ... CFn × (PWFn)	
PV	Present value $
CF	Cash flow or income for the period specified $
PWF	End of period present worth factor, equals $1/((1+i)^n)$
i	Discount rate (the period compound interest rate)
n	Period for the present worth factor being calculated

An estimate of each year's expected income (cash flow) is necessary to estimate the present value (PV). The number of periods – n (usually years) – used in the analysis is the number of years that the mineral property is expected to produce a positive net income.

DCF formulas vary based on when the money is received; i.e., continuously, beginning of period, middle of period or end of period. The period may be continuous, daily, monthly, quarterly, biannual or annual. Many oil properties are evaluated using an annual mid-period discounting variation of the DCF formula shown in **Exhibit 3**.

EXHIBIT 3

Present Worth Factor for Mid-year DCF PWFMY = $1/((1 + i)^{(n - .5)})$	
PWFMY	Mid-year present worth factor
i	Discount rate (the period compound interest rate)
n	Period for the present worth factor being calculated

[19] Appraisal Institute, *The Appraisal of Real Estate*, 15th ed. (Chicago: Appraisal Institute, 2020), Pp. 478-479.

Appendix A, Figure 2 illustrates how a DCF is calculated for a mineral property using a mid-year factor.

Discount Rate Components

The discount rate components used in DCF analysis are the inflation rate, risk-free component, general risk premium and property-specific risk premium.

Inflation rate: the annual rate of price change for a basket of consumer goods.

Inflation is normally measured by the Consumer Price Index for All Urban Consumers (CPI-U), calculated by the U.S. Bureau of Labor Statistics. The inflation rate is the most basic component of a discount rate. An investor's rate of return must equal the inflation rate just to break even in real dollar terms.

Risk-free component: a return to compensate the investor for a loss of liquidity (risk-free rate minus the inflation rate).

The risk-free rate is the inflation rate plus a return to reimburse the investor for a loss of liquidity. It is measured by the yield to maturity on U.S. government securities with a maturity period comparable to the investment under consideration (oil or gas reserves). The market perceives U.S. government securities as risk-free for all practical purposes.

General risk premium: a return to compensate the investor for assuming diversified company-wide risk.

The general risk premium is the WACC minus the risk-free rate. To measure WACC, weight the typical oil company debt and equity costs by the typical oil company debt and equity capital structure percentages, and then add the weighted costs. When appraising companies, the WACC is the discount rate, because it reflects the market's expected yields from the stock and debt of a company.

For property tax purposes, appraisers estimate the value of individual mineral reserves, not the value of oil companies. Buyers of mineral reserves usually perceive individual reserves as riskier than the stock and debt of an entire company. Companies can spread their risk over many individual mineral reserves and often over several kinds of assets (some may be unrelated to oil or gas). This asset diversification reduces the company's risk and, as a result, the WACC derived from company financial data is usually lower than an individual producing property's discount rate. The WACC, however, is always higher than the risk-free rate. This rate increase is a general risk premium to reward investors for assuming the diversified company-wide risk.

Property-specific risk premium: a return that compensates the investor for assuming the unique risks associated with a mineral-producing property.

The property-specific risk premium is the discount rate minus WACC. Investors demand a premium above the WACC to compensate them for individual property risk. This premium can be quite high for high-risk property.

EXHIBIT 4

Discount Rate Component Summary	
	Inflation rate
+	Risk-free component
+	General risk premium
+	Property-specific risk premium
=	Discount rate

Exhibit 4 summarizes how these components determine the discount rate. The first three components are quantifiable from public data. In some cases, the property-specific risk premium may be derived from available data, but the appraiser generally must estimate it. Refer to **Appendix A, Figure 11** for conditions that must be considered when estimating the property-specific risk premium.

DCF Method Techniques

The acceptable techniques for estimating discount rates using the DCF method include market surveys, oil and gas sales analysis and WACC (or band of investment). Ideally, the appraiser uses these three techniques simultaneously to develop a range of discount rates.

A typical WACC sets the lower limit while surveys and direct sales analysis provide a set of discount rates the appraiser can use as a database to estimate a mid-range discount rate and an upper limit to the discount rate. Examples of these techniques are found in **Appendix A, Figures 3-10**.

Some mineral properties may sell at or below the purchaser's WACC. One reason why is that a buyer (or appraiser) reduces the cash flows to account for reserve recovery risk; the discount rate will not reflect the risk, but the purchase price will. To calculate a discount rate that is comparable to discount rates from other sales, the appraiser must quantify the risk adjustment and add it back to the cash flows. This discount rate will be higher than the non-risk-inclusive rate.

Atypical income tax deductions or abnormally high or low overhead can also create an artificially high or low discount rate. When faced with market evidence that indicates a discount rate at less than a company's cost of capital, the appraiser reviews all appraisal parameters to determine why an abnormally low discount rate is indicated. An understated income stream is the most obvious reason. The appraiser may adjust the cash flows to derive a market discount rate or may delete the sale from consideration.

Market Surveys

An appraiser may use market surveys as an indicator of the discount rate. Many studies and surveys are published to help the appraiser estimate an appropriate discount rate, or range of rates, for appraising oil and gas properties. The Society of Petroleum Evaluation Engineers' (SPEE) Annual Survey asks producers', consultants' and bankers' opinions on future prices, cost escalation and economic indices (including the discount rate) used in petroleum property evaluation. **Appendix B** shows the formula for calculating the oil and gas price escalation/de-escalation percentage.

Market surveys result in rates that include all the discount rate components, but the rate included for the property-specific risk premium is the typical rate for the properties included in the survey. The appraiser must estimate the property-specific risk premium and adjust for atypically high or low risk. The appraiser must reduce the risk premium for properties with less than the typical risk and increase the risk premium for properties with more than the typical risk.

Oil and Gas Sales Analysis

Exhibit 5 lists the three basic steps used to develop a discount rate from sales.

EXHIBIT 5

Developing a Discount Rate from Sales
1. Obtain recent sales prices from a variety of oil- and gas-producing properties.
2. Develop cash flow projections for each property.
3. Calculate for each sale the internal rate of return (IRR), also known as the DCF return on investment (DCFROI).

Step 1: Obtain Sales

The best source for sales information is the buyer or seller. Other sources that list oil and gas property sales include the Texas Railroad Commission, Oil and Gas Journal, private firms and oil and gas companies. It is important to remember that the sale of an oil or gas property must be a market transaction when developing a discount rate from sales.

Like market surveys, sales analysis results in rates that include all of the discount rate components. The appraiser must estimate the property-specific risk premium (unless the sales sample is directly comparable to the property being appraised) and adjust for atypically high or low risk.

Step 2: Develop cash flow projections

The appraiser develops cash flow projections for each property using the verified sales prices. To the extent possible, the appraiser must talk with the parties to each sale to determine their expectations of the property. The derived discount rate's validity is a direct function of the buyer's and seller's cash flow projections. The appraiser must incorporate this information into the projections. If the appraiser's projections differ from the buyer's and seller's expectations, the discount rate derived from the sale will be invalid.

Step 3: Calculate the internal rate of return (IRR)

The IRR is the yield (discount) rate at which the cash income stream's present value equals the cash expenditure's present value (the sales price in our analysis) necessary to produce that income stream. This discount rate is prospective; it depends on the market's expectation of future performance rather than the historical performance of the property. The discount rate at which the cash flow's present value equals the sales price can be determined by trial and error or by using calculators and computer software that solves for the discount rate (IRR).

This measure is also referred to as the profitability index and investor's method. The IRR recognizes that funds received now are more valuable than those received at some future date. The investment outlay can be regarded as borrowed funds and the pre-tax cash flow as the payment of principal, plus compound interest on the investment.

Weighted Average Cost of Capital (WACC)

This third technique (aka band of investments) produces a rate that does not contain a component for property-specific risk. Because it lacks this component, potential purchasers' typical WACC sets a minimum value for a discount rate. The appraiser must calculate the typical WACC of potential purchasers to know this lower limit. On a case-by-case basis, the appraiser excludes oil companies from the WACC calculation if they cannot participate in the market for the subject property. For instance, small companies may not be able to bid on certain high-valued oil and gas properties due to insufficient capital. A typical WACC for larger oil companies would establish an appropriate minimum discount rate for appraising the subject property.

An investor should not buy a property at a discount rate lower than the WACC; otherwise, the investor's net worth will decrease. The appraiser must add the property-specific risk premium to potential purchasers' typical WACC to develop a discount rate.

The basis for this analysis is financial data from a broad sample of oil companies that derive most of their operating revenues from oil and gas production. Since petroleum property valuation typically involves discounting cash flows over a long period of time, a long-term cost of capital is most appropriate for developing an oil or gas property discount rate. The appraiser incorporates a broad time series of data to approximate a long-term cost of capital. **Exhibit 6** lists the four steps used to calculate WACC.

EXHIBIT 6

Calculating the WACC
1. Derive the typical capital structure and express it as a proportion of debt and equity.
2. Calculate the typical cost of outstanding debt based on bond yields.
3. Compute the typical cost of equity using the capital asset pricing model (CAPM) or another method, such as the DCF model.
4. Weight debt and equity costs according to the typical capital structure percentages to derive a typical cost of capital.

Step 1: Derive capital structure

Capital structure describes in percentages the funds (capital) used to purchase the assets necessary to operate a company. Debt and equity comprise the capital structure of any company. The debt portion consists of long-term debt (outstanding bonds) and preferred stock, while the equity portion consists of outstanding common stock. If the company is funded by debt and equity of equal value, the capital structure is 50 percent debt and 50 percent equity.

To estimate a discount rate for mass-appraisal purposes, the appraiser uses the typical market capital structure for a representative group of major and independent oil companies that derive most of their operating revenues from oil and gas production.

Step 2: Calculate cost of outstanding debt

The yield-to-maturity is the best approximation of the cost of debt capital. This yield is observable in the marketplace and can be found by referring to Standard and Poor's Capital IQ, Moody's Bond Report or comparable publications. Additional resources for yield-to-maturity information include Value Line, Morningstar, Yahoo Finance, Bloomberg Bond Record, Damodaran, Fidelity, Duff & Phelps and Zacks.

Step 3: Compute cost of equity

The capital asset pricing model (CAPM) is the preferred approximation of equity cost because it considers both historical market yields and current expectations, plus a market-derived equity risk factor. The CAPM method measures the cost of equity by considering that an investor's required rate of return on common stock includes a risk-free return, plus a risk-adjustment factor related to the specific stock. **Exhibit 7** shows the CAPM equation and defines its factors.

EXHIBIT 7

CAPM Equation K = Rfc + B(Rm - Rfh)	
K	Cost of equity (after tax), percentage/year
Rfc	Current risk-free rate, percentage/year
Rm	Historical market return on equities and common stocks, percentage/year
Rfh	Historical market return on long-term government bonds, percentage/year
B	Beta coefficient

The current risk-free rate (Rfc) is typically based on current, long-term government securities (i.e., the yield-to-maturity observed on an annual basis on a default-free Treasury bond, note or bill) of the relevant time period. For oil and gas property appraisal, the yield on a long-term bond is an appropriate measure of the risk-free rate.

Duff & Phelps SBBI® Yearbook – Stock, Bonds, Bills and Inflation provides the historical market return on equities (Rm) and common stocks and the historical arithmetic mean on long-term government bond income returns (Rfh). The beta coefficient (B) measures market risk by regressing the stock's total return against the market's total return. Duff & Phelps SBBI® Yearbook offers a detailed description of the beta calculation. Sources for the beta coefficient value include Value Line Publishing Inc.'s The Value Line Investment Survey, Standard and Poor's Corp.'s S&P Stock Reports and similar investment services.

The difference between the historical risk-free (Rfh) and market (Rm) rates of return is a measure of the non-systematic (non-market) related risk caused by changes specific to the companies comprising the stock rate of return sample and is, in effect, an equity risk premium. Note that the CAPM uses two different risk-free rates of return. The current risk-free rate (Rfc) acknowledges the expectational function of the model. To calculate the equity risk premium, use the historical risk-free rate (Rfh) in conjunction with the historical market return (Rm) for the same time period.

The cost of equity resulting from this model is a nominal (current dollar) after-tax rate. Conversion to a nominal, pre-tax rate requires dividing the equity cost (K) by 1 minus the federal statutory income tax rate for petroleum companies. The equation K(pre-tax) = K/(1 - .21) represents the current 21 percent income tax rate.

If the appraiser calculates a typical effective income tax rate from a representative sample of petroleum companies that could participate in the market for the subject property, the appraiser may substitute that typical effective income tax rate for the statutory rate.

Step 4: Weight debt and equity costs

Once capital structure, debt and equity costs are determined, the final step in deriving the WACC is to weight the cost of debt and equity by the proportional share each has in the overall capital structure. **Exhibit 8** shows the equation for each, and **Exhibit 9** shows the discount rate component expanded. **Appendix A, Figures 3-6** illustrate the WACC estimating technique.

EXHIBIT 8

Capital Structure		
Weighted average cost of equity	=	(cost of equity percentage) X (equity fraction)
Weighted average cost of debt	=	(cost of debt percentage) X (debt fraction)
Weighted average cost of capital	=	weighted average cost of equity + weighted average cost of debt

EXHIBIT 9

Discount Rate Component Summary	
	Inflation rate
+	Risk-free component
=	Risk-free rate
	Risk-free rate
+	General risk premium
=	WACC

Final Discount Rate Selection

The typical WACC of potential purchasers sets the lower end of the discount rate range. To help establish the upper end of the discount rate range, the appraiser can calculate a standard deviation of all the discount rates indicated by the sales sample and the survey. One standard deviation above and below the mean contains 68 percent of all the observations in a normally distributed set of data. Two standard deviations above and below the mean contains more than 99 percent of all the observations in a normally distributed set of data. Although the data may not be normally distributed, this kind of analysis may help the appraiser to establish the upper end of the discount rate range.

High-risk properties (e.g., a one-well lease with high water production near the end of its economic life) may be discounted by the market at two standard deviations above the mean. Properties with lesser risk will have correspondingly lower discount rates. One standard deviation above the mean may establish an upper limit for properties in a typical risk-range. The mean or median of the discount rates from the sales analysis and the survey indicate the mid-range discount rate.

For a standard deviation analysis to have meaning in selecting an upper limit to the discount rate range, the survey or sales dataset must contain properties with broadly varying risk. A high-end discount rate selected by this method will not apply to very risky properties (it will be too low) unless the sales dataset used in the analysis contains similar risky properties.

To select a discount rate for an individual property, the appraiser must assess the property-specific risk inherent in the property.

Appendix A: Discounted Cash Flow Examples

The values used in the examples in these figures are for demonstration purposes only.

FIGURE1
DCF Method Example (Working Interest Only)

Year	(1) Net Oil Production (bbls)	(2) Oil Price ($/bbls)	(3) Gross Income ($)	(4) Op. Exp.+ Sev. Taxes* ($)	(5) Net Income ($)	(6) Discount Factor @15.67%	(7) Discounted Cash Flow ($)
1	31,938	56.26	1,796,832	159,015	1,637,817	.929800	1,522,842
2	25,550	54.43	1,390,687	159,341	1,231,346	.803839	989,803
3	20,440	55.11	1,126,350	160,692	965,658	.694941	671,076
4	16,352	55.79	912,258	162,946	749,312	.600797	450,184
5	13,081	56.48	738,826	165,982	572,844	.519406	297,538
6	10,465	57.18	598,404	169,733	428,671	.449041	192,491
7	8,372	57.89	598,404	174,115	310,547	.388209	120,557
						Subtotal	**$ 4,244,492**
				Salvage	$ 10,000	.360956**	3,610
						Total	**$ 4,248,101**

* Operating expenses plus severance taxes
**Note: End-of-year-seven factor = $1/(1+.1567)^7$

FIGURE 2

DCF Calculation Procedures

1. Net oil production is gross oil production multiplied by net revenue interest (NRI), which equals 87.5 percent.
2. Starting oil price equals $56.26 per barrel with an escalation rate of 4 percent per year.
3. Gross income equals net oil production multiplied by oil price.
4. Operating expenses plus severance taxes: Operating expenses escalated at a rate of 4 percent per year. Severance tax on oil is 4.6 percent per year.
5. Net income equals gross income less operating expenses and severance taxes.
6. Discount factor (mid-year) @15.67 percent equals:

Year	Formula		Discount Factor Percentage
1	$1/((1+.1567)^{(1-.5)})$	=	.929800
2	$1/((1+.1567)^{(2-.5)})$	=	.803839
3	$1/((1+.1567)^{(3-.5)})$	=	.694941
4	$1/((1+.1567)^{(4-.5)})$	=	.600797
5	$1/((1+.1567)^{(5-.5)})$	=	.519406
6	$1/((1+.1567)^{(6-.5)})$	=	.449041
7	$1/((1+.1567)^{(7-.5)})$	=	.388209
NOTE: The discount factor of 15.67 percent includes 1.85 percent for property taxes. Some appraisers handle property taxes as a deduction from gross income.			

7. DCF equals net income multiplied by the discount factor.

The DCF method should also include capital expenditures, environmental remediation costs and the present worth of equipment salvage value less well-plugging costs.

FIGURE 3

Estimation of WACC

1. Derive the typical capital structure of a broad sample of potential purchasers as a proportion of debt and equity. Data can be found in the 12/31/20xx issue of "The Value Line Investment Survey" under Petroleum (Integrated) Industry and Petroleum (Producing) Industry.

Outstanding common stock (oil company)	=	157,627,284 shares @ 12/31/20xx
Closing common stock price	=	$106.75/share
Common stock equity	=	157,627,284 shares X $106.75/share
	=	$16,827,000,000 @ 12/31/20xx
Total debt	=	$6,791,000,000 @ 12/31/20xx
Total capital	=	Debt + equity
	=	$6,791,000,000 + $16,827,000,000
	=	$23,618,000,000
Debt	=	$6,791,000,000/$23,618,000,000
	=	.288 or 28.8 percent
Equity	=	$16,827,000,000/$23,618,000,000
	=	.712 or 71.2 percent
The capital structure is 28.8 percent debt and 71.2 percent equity.		
Repeat this procedure for each company in the sample.		

FIGURE 4

Calculating the Cost of Outstanding Debt

2. Calculate the cost of outstanding debt. YTM = yield-to-maturity* @ 12/31/20xx

Debt Instrument	Debt (MM$)	YTM (% per year)	Debt X YTM ($)
Debt A	27	6.29	170
Debt B	586	8.42	4,934
Debt C	132	7.52	993
Debt D	600	7.84	4,704
Debt E	265	4.95	1,312
Debt F	100	8.65	865
Debt G	300	7.87	2,361
Debt H	450	8.28	3,726
Debt I	123	8.70	1,070
Debt J	224	8.78	1,967
Debt K	300	8.29	2,487
Debt L	500	8.38	4,190
Totals	**$ 3,607**		**$ 28,779**

Sum of debt	=	Debt (MM$) X YTM
	=	$28,779 MM
Cost of debt	=	Sum of debt (MM$)/Debt (MM$)
	=	($28,779 MM)/($3,607 MM)
	=	7.98 percent per year
Repeat this procedure for each company in the sample.		

*Note: Resources for yield-to-maturity information include Standards & Poor's, Value Line, Morningstar, Yahoo Finance, Bloomberg Bond Record, Damodaran, Fidelity, Duff & Phelps and Zacks.

FIGURE 5

Calculating the Cost of Equity Equation

3. Use the capital asset pricing model (CAPM) equation.

K = Rfc + B(Rm - Rfh)		
K	Cost of equity (after tax), percentage per year	
Rfc	Current risk-free rate, percentage per year*	2.26% per year
Rfh	Historic market return on long-term government bonds, percentage per year**	5.90% per year
Rm	Historic market return on equities, percentage per year**	11.90% per year
B	Beta coefficient***	1.70
K	=	Rfc + B(Rm - Rfh)
	=	2.26 + 1.70 (11.90 - 5.90)
	=	12.46 percent per year
K (pre-tax)	=	12.46/(1 - .21)
K	=	15.77 percent per year

*Federal Reserve Statistical Release (January of current year)

**Duff & Phelps SBBI® Yearbook – Stocks, Bonds, Bills and Inflation®

***The Value Line Investment Survey, 4th Quarter, 20xx

FIGURE 6

Calculating a Typical WACC

4. Calculate a typical WACC by plugging the mean (or other measure of central tendency) cost of debt, cost of equity and capital structure from the sample companies.

WACC	=	((cost of debt) X (percent debt)) + ((cost of equity) X (percent equity))
	=	(7.98 X .288) + (15.77 X .712)
	=	13.53 percent/year

FIGURE 7

Average the Data Arithmetically

The standard deviation is the square root of the average squared difference between the individual observations and the average value. The first step in calculating the standard deviation is to average the data arithmetically. The arithmetic average or mean value is denoted as z.

z = 1/n(x1 + x2 + x3 + ... + xn)	
z	Mean value of a data set of n values
x1	Unique value in dataset
n	Total number of values in data set

FIGURE 8

Standard Deviation

The standard deviation is denoted by the symbol S.

$S = (((x1 - z)^2 + ... + (xn - z)^2)/(n-1))^{.5}$	
S	Standard deviation of a dataset with n values
x1	Unique value in dataset
xn	nth value in dataset
n	Total number of values in dataset

FIGURE 9

Standard Deviation Example

Procedure for calculating the standard deviation of a dataset that includes 10 sales with various internal rates of return (IRR).

Sales No.		IRR (%)	(x - z)	$(x - z)^2$
1	X 1	11.0	-4.7	22.09
2	X 2	25.0	9.3	86.49
3	X 3	6.0	-9.7	94.09
4	X 4	16.0	0.3	0.09
5	X 5	16.0	0.3	0.09
6	X 6	22.0	6.3	39.69
7	X 7	9.0	-6.7	44.89
8	X 8	14.0	-1.7	2.89
9	X 9	13.0	-2.7	7.29
10	X 10	25.0	9.3	86.49
Totals		**157.0**		**384.10**

FIGURE 10

Calculating the Standard Deviation

1. Calculate the arithmetic average z.

z	=	Sum(IRR (%)/Sum(Sales No.)
	=	157.0/10
	=	15.7

2. Calculate the arithmetic average S.

S	=	Sum((x - z)^2)/Sum(Sales No.) - 1))$^{.5}$
	=	(384.1 / (10 - 1))$^{.5}$
	=	6.5

3. Calculate the range of 1 standard deviation.

	=	z ± S
	=	15.7 ± 6.5
	=	9.2 < 15.7 < 22.2

4. Calculate the range of 2 standard deviations.

	=	z ± S(2)
	=	15.7 ± 6.5(2)
	=	2.7 < 15.7 < 28.7

28.7 percent per year is the upper range of the discount rate for high-risk properties.

FIGURE 11

Property-Specific Risk Factors

Property-Specific Risk Factors
One well lease
Oil lease with high water production
Lease near the end of its economic life
Gas well reservoir under partial or active water drive (recovery uncertain)
Curtailed gas well
Rapidly declining lease
Lease with less than six (6) months' production history
Secondary recovery project in early stages before fill-up
Offshore oil or gas lease
Unusually high operating expenses (e.g.: paraffin problems, sour gas etc.)
The appraiser should add any other property-specific factors that increase the investor's risk to the base discount rate (WACC).

Proposed Version

Appendix B: Escalation or De-escalation Formula

This is the formula for determining the maximum average annual escalation or de-escalation percentage of crude oil and natural gas prices for years two through six of the appraisals.

$((X/100)^{(1/Y)}-1) \times 100$	
X	Most recent year annual average (not seasonally adjusted) producer price index (PPI) for crude petroleum (domestic production) [Commodity Code 0561, Series ID# WPU0561] or natural gas [Commodity Code 0531], obtained from the U.S. Bureau of Labor Statistics during the month of January, which may contain preliminary statistics.
Y	Number of years from base year 1982 through the most recent year (most recent year minus base year).
	The denominator of 100 in the formula is the PPI annual average for domestically produced petroleum and natural gas in base year 1982.

Most recent year	=	2019
X	=	157.8 for crude petroleum domestic production (Commodity Code 0561) [Series ID# WPU0561]; 185.8 for natural gas (Commodity Code 0531)
	=	2019 - 1982 = 37 years
1/Y	=	1/37
	=	0.027027027

Crude petroleum (domestic production)	=	$((157.8/100)^{0.027027027} - 1) \times 100$
	=	1.240 percent
Natural gas	=	$((85.6/100)^{0.027027027} - 1) \times 100$
	=	-0.419 percent

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