FINANCING SUSTAINABLE WATER
Rates. Revenue. Resources.

Alliance for Water Efficiency

Sustainable Utilities: Financial Instruments to Manage Weather-Related Revenue Risk

July 2014

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Foreword

In 2012, the Alliance for Water Efficiency (AWE) convened 30 leading water utility finance managers, rate experts, academics, economists, regulators and advocates at a Summit to discuss a troubling trend in the water industry: the decline of water utility revenues across the nation and cutbacks in water efficiency investments, which were perceived to be responsible for this slowing of sales. This two-day discussion revealed that more efficient water use was just one piece of the puzzle. A host of factors – including unpredictable precipitation patterns, more water-efficient fixtures and appliances being installed because of standards and codes requirements, economic shifts, and gaps in overall financial planning – were all partly responsible for causing this revenue instability.

As the leading voice for sustainable and efficient water use in North America, AWE is dedicated to protecting and expanding investments in water efficiency. Following this discussion, AWE set out to identify, develop and disseminate solutions to help utility managers navigate this minefield of challenges.

One novel idea that surfaced during that 2012 discussion was the use of financial tools – such as derivatives and insurance – to mitigate the financial impact of risks like volatile weather. Although these tools are used frequently by the agricultural and energy sectors, it was a solution that had not yet been closely explored in the context of water supply management. In light of the rapidly evolving and increasingly volatile weather patterns, AWE deemed it a topic for serious investigation.

In 2013, AWE engaged a consultant with extensive experience in weather risk hedging to determine how these tools might be applied by water finance managers to better manage the financial risks of unexpected weather events – ranging from extremely wet years to prolonged drought or insufficient snowpack.

In April 2014, AWE reconvened this same group of leaders – along with new voices – and introduced this idea as a possible strategy for water managers to manage this growing risk. A fruitful discussion ensued as the group delved into numerous concerns related to utilizing such tools in an industry that provides such a critical public service, and which has typically not engaged in financial market activity.

The group agreed that utilities must continue to strive for wise financial management through cost-based rate setting practices that incentivize efficient use and ensure a reliable revenue stream. Through discussion, however, it was determined that both of these traditional strategies had significant embedded risks of their own. Both political risk related to rate increases and the risk of stranded infrastructure carry a high implicit and explicit cost.

While participants expressed concern that profits were being made on these hedges, they also recognized that all vendors seek a profit when they contract with a water utility. Additionally, the question of "who pays" for such a tool was discussed, examining ways a utility might pass on the cost of a weather hedge to large outdoor users in a fair and equitable manner.

In addition to the financial protection these market-based and insurance products provide to utilities, the discussion revealed yet another benefit for utilities seeking to secure a sustainable financial position. Rating agencies – a representative of which participated in the second Summit – view these types of financial tools as an acceptable means of risk mitigation. In fact, it was noted that if a water utility was perceived as potentially being unable to push through needed rate increases, then having a third party contract with a highly rated counterparty would be viewed favorably and could improve the utility's credit rating.

At the conclusion of the Summit, the majority of this group agreed that these instruments could be a viable strategy to add to the utility manager's toolbox for increasing fiscal sustainability, and that they should be further explored by the industry.

This initial white paper serves as introduction to the diverse tools that exist today to manage weather risk and how they function. It is AWE's intent that this document spark discussion and further investigation into how these tools might be appropriately structured and priced to help utilities better protect their fiscal viability and ability to serve customers with clean, reliable and affordable water service for years to come.

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Introduction

Water utilities nationwide are increasingly experiencing significant financial challenges associated with their missions to deliver a long-term, safe and affordable supply of water to customers. Partly due to unpredictable weather patterns, changing socioeconomic conditions and characteristics, changes in codes and standards, successful water conservation programs, and a number of other factors, both water sales and water-related revenues are falling on a national level[1]. With sales and revenues declining, water utilities are stretched to cover the increasing costs of water treatment and delivery, as well as the long-delayed and rising costs of infrastructure repair and replacement. Most importantly, they are unable to meet these costs while still encouraging conservation efforts critical to sustaining strained water supplies.

Utilities currently employ a number of techniques and are exploring various new solutions to help stabilize utility revenues and ensure long-term financial viability – including new approaches to rate setting, legislative and regulatory changes, and financial management strategies.

The idea of exploring risk-sharing mechanisms and financial instruments to mitigate risks has recently emerged as a potential solution. Entities in the agricultural, mineral, and energy sectors often hedge against financial risks by purchasing futures contracts, derivative contracts, or insurance products. The weather risk management market, which can offer financial solutions packaged in any of these formats, in particular may present a promising opportunity for water utilities. Weather patterns shift continuously but also can be persistent. Extremely wet or dry seasons, or even worse, a few in a row can have a significant impact on a utility's sales, net revenue, debt service coverage ratios, and ultimately force a lower debt rating which will then lead to increased interest expense for a sustained period of time. A number of weather-related financial instruments currently exist and are utilized successfully in industries such as energy and agriculture, and have also been previously used by municipalities.

This is an introductory examination of the financial instruments available in the market place to mitigate weather risk and which could potentially be used by public water suppliers around the globe to better manage weather-related revenue losses. This paper explores these weather-based financial instruments and assesses when and how the water industry can use them effectively. Most importantly, it offers concrete examples so that water utilities can see how these hedging tools can effectively decrease the volatility in a municipality's budget, and decrease risks to revenues and/or costs.

[1] Declining Water Sales and Utility Revenues: A Framework for Understanding and Adapting, Alliance for Water Efficiency, 2012 (http://www.allianceforwaterefficiency.org/Declining-Sales-and-Revenues.aspx)

Overview of Financial Instruments for Risk Mitigation

Organizations desiring to shed unwanted risk through the purchase or sale of financial instruments have several options. The primary financial risk mitigation tools available are financial derivatives, exchange cleared futures, or buying insurance. All three are useful and have their particular place in the management of undesirable risk.

Financial Derivatives

Derivatives are the most flexible and diverse set of tools available to manage unwanted risk. A water utility can customize an index to match or closely mimic the risk profile it faces. The index can be created to manage a volumetric risk (e.g., precipitation or stream flow), price risk (e.g., operating and maintenance costs related to energy consumption), or a combination of both volume and price (a quantity-adjusting or "quanto" structure). Quanto structures provide a vehicle to hedge against multiple variables that may impact revenue.

The level of protection bought in a derivative contract is flexible and can cover risks that happen at any level of frequency (0.001% to 99%). Assuming an index is chosen that is based on a published market number (e.g., it can be inches of rainfall, the kcfs a stream exhibits, the price of oil, etc.), the settlement of a derivative contract is simple and payments occur within days of the contract's Settlement Value being calculated per a pre-determined formula defined in the contract. This payment occurs without a "test of loss" by the owner of the derivative contract. In customizing its own index, a water utility can then buy or sell options for a finite premium, execute a combination of buying an option and selling another option to fully or partially offset the cost of the purchased option (i.e., collar), or execute swaps that have no upfront cost.

Derivatives have been used for decades and are regulated by federal governments around the world. Due to the sound legal system that exists in the United States (and many other countries), the enforceability of these contracts is strong because they are largely governed through International Swaps and Derivatives Association (ISDA) master agreements. These master agreements also cover financial risk mitigation tools most water utilities already use to manage interest rate risk.

Derivatives also offer tremendous flexibility after their initial execution because the contracts can be wholly or partially monetized at any time at the discretion of a water utility manager who is dealing with a constantly changing environment. Finally, the accounting treatment of derivatives is typically well defined per accounting standards and, with regards to weather derivatives, relatively flexible.

Exchange Cleared Futures

Exchange cleared futures are financial tools for sharing risk that are regulated by an exchange such as the Chicago Mercantile Exchange. These instruments have set expiration dates. These instruments also require standardized indices (such as cumulative rainfall or snowfall at a set of locations or commodity prices at a particular pricing hub) and therefore are not as flexible for mitigating risk as derivatives. These instruments require the posting of margin as their value changes as defined by the exchange. Futures trade without a premium being paid up front (much like a swap in derivatives). Option contracts can be traded on futures contracts and sometimes these options are executed through the Exchange. For companies that trade fairly standardized products such as oil, natural gas, and grains, these are extremely popular instruments with relatively high numbers of counterparties that compete for the business and bring tremendous liquidity and price transparency to the marketplace. Accounting rules for exchange traded contracts are very specific and vary by product purchased.

Insurance

Insurance is more regulated (usually on a state-by-state basis within the United States) and with this regulation generally comes a higher cost and a less flexible risk mitigation contract. These contracts must indemnify a defined loss (which must be contractually capped) for the buyer of the contract. Proving that a defined loss has occurred is critical to assuring a payment is made from an insurance company to an insurance buyer. The claim process can be difficult depending on the circumstances and in almost all instances is more cumbersome than the settlement of a derivative or exchange cleared futures contract because of the involvement of an insurance adjustor that must document the proof of loss to the insurance buyer. Insurance contracts are not easily adjusted once they are put in place, and always involve the payment of a premium for their risk mitigation contract. Insurance contracts are typically voluminous with several details of critical importance in the footnotes of the contract that are unique to each underwriter.

Even with these shortcomings, insurance should always be considered, especially if the risk of loss is easily defined. Most insurance companies underwrite low probability risks (with most usually offering well-priced policies for risks with probabilities of occurrence between 1% and 15%). There are additional underwriters that will take on very low probability loss events of sub 1% and also more frequent loss scenarios of up to 25%; but the number of insurance underwriters that offer policies that are priced acceptably with the buyers of such policies at these levels of coverage become increasingly scarce. Insurance also has its own accounting rules which some find advantageous.

Brief History of the Weather Risk Management Market

Weather patterns are largely unpredictable and increasingly volatile, creating risk for many business operations. While extreme weather events such as hurricanes, tornadoes, and flooding pose risks to human life and infrastructure, even subtle changes in weather, such as higher-than-normal precipitation, can bring devastating financial losses to a range of industries and businesses. A temperature change of a few degrees per day on average or a few inches of snow or a late frost can significantly harm or even destroy a crop. Drought can force water municipalities to seek much more expensive sources of water in order to meet their customers' demands. If water is used for hydroelectric generation, a lack of water can force a utility to seek alternative and costly power sources to meet their contractual commitments. Abnormal temperatures and precipitation events can ruin a retailer's sales on a given day or even season. All of these losses are observed and reported almost daily in the global media.

Weather risk can and has frequently been mitigated over the centuries. In early commercial arrangements, informal agreements were put in place to barter goods or services if a tragic weather event occurred. The party suffering the loss from weather would ask for assistance from a neighbor or the greater society. While this help was occasionally granted through sincere generosity, more frequently it was granted with an expectation of repayment in the form of labor or other goods. Forward contracts were introduced in agriculture markets as another means to shed weather risk. Crops were sold forward at a price that gave the farmer certainty of a market and at a price that covered weather risk in addition to other perils.

Eventually, insurance contracts were offered to cover catastrophic weather events. These insurance contracts continue to be offered today to cover the damage from all sorts of natural and catastrophic events such as hail, hurricanes, flooding, and drought. These contracts are offered to residential and commercial customers by a wide range of reputable insurance dealers such as Nationwide, State Farm, All State, and Farmers Insurance; and on a corporate level through the insurance subsidiaries of large reinsurance companies such as Allianz Re, Axa Re, Axis Re, Endurance Re, Munich Re, Swiss Re, and Zurich Re. Farmers remain one of the largest customer bases for multi-peril insurance which has a significant weather component to its risk profile. In some instances, regional and federal governments have subsidized insurance companies to take on what is substantially weather risk inside crop insurance policies that frequently cover catastrophic risk.

In the 1990s, the derivative market embraced weather risk. The weather derivative market arose to meet the risk mitigation needs of energy companies. Energy companies were using derivatives and exchange cleared futures contracts to manage price risk. Realized weather risk was a secondary risk embedded in price and a primary risk for determining the volume of a commodity consumed in the market. Temperature, in particular, was directly impacting the volume requirements the energy industry experienced for propane, heating oil, natural gas, and power, and it also had a strong influence on prices of the underlying commodities.

Initially, the weather derivative market focused on temperature derivatives. By the early 2000s, the weather risk accepted by the weather derivative market place expanded to cover wind, precipitation, and streamflow. These new weather variables were driving the available supply of renewable energy in the market. The introduction of precipitation risk in the marketplace further allowed the agriculture community to embrace weather derivatives. Soon, the agriculture market saw the uses for managing discrete weather risks in the form of temperature and precipitation as a favorable economic alternative or in many cases a supplement to various forms of crop insurance.

Because the derivative market was taking some market share from the insurance industry and was actually finding risk contracts that were offsets to their traditional underwritten risks, the reinsurance community entered the weather derivative market. Today, the market consists of insurance/reinsurance, hedge funds, and banks serving as the main absorbers of weather risk. Those shedding weather risk are typically end users such as energy utilities and project developers, the agriculture industry, transportation and construction companies, and municipalities.

In 1999, the Chicago Mercantile Exchange (CME) launched their first weather futures contracts and derivatives on those futures contracts (i.e., flexible strike options using the same indices and locations for measurement as the futures contracts). The CME initially listed only temperature indices at approximately 20 US locations. These trading instruments were widely used especially following the failure of Enron and other energy merchants in the early to mid-2000's. The CME brought much needed credit risk management services to the market during this time and the number of contracts executed on the CME correspondingly peaked. Since then, the CME has launched additional indices and locations including those for cumulative rainfall and snowfall, but with very modest success.

The main reason for this marginal success has been the improvement in credit markets, which promotes more party to party (i.e., Over the Counter) transactions, and the rigidness of the contracts provided by the CME that limits their use. Most futures contracts provide end users a tool that leaves substantial and unwanted risk (i.e., "basis risk") with that entity. The CME continues to be the primary exchange in the world with weather products listed and transacted upon. Temperature indices continue to dominate the volume of trades the exchange oversees.

There have been a few attempts to offer weather derivatives embedded in bonds. The most notable success was Koch Industries' Kelvin Bond, which was a 144a private placement that went to market in 2000. It had over 25 forms of customized temperature risk embedded in it. The realized temperature results ultimately impacted the amount of principal repayment and the interest rate paid by Koch Industries each year of the note's three-year life. This bond was issued in an attempt to broaden the market place and to help Koch's energy subsidiary manage its risk profile associated with its growing weather derivative business. Several financial players invested in these bonds. But in general the success of this bond issuance was questioned, because of the relatively high issuance cost relative to the amount of risk transferred and the fact that many of the investors also were set up to trade the underlying derivatives outright versus needing to buy them in bond form. Goldman Sachs served as the placement agent for Koch Industries' bond. Risk Management Solutions (RMS – a well-known catastrophic risk modeling company) performed the modeling of the risk for the investors. Others have tried to place pure weather bonds, but all have occurred with only modest success. Some retail investment notes have been issued by banks (e.g., ABN AMRO) with variable interest rates tied to weather related events, and some corporates have done so as well. For example, Electricite de France issued a bond called Pylon to protect its transmission asset portfolio and end user demand from unusually high winds. But a majority of structured notes have continued to be issued with interest rates moving with the price of a hard commodity such as sugar, oil, wheat, corn, etc. or with a catastrophic event like hurricanes or earthquakes (i.e., catastrophe bonds or "Cat Bonds").

Historical Examples of Weather Risk Mitigation by Municipalities

Many municipalities have executed a range of instruments in the weather derivative market to manage weather-related risk. Below are a few transactions that have been executed:

- A relatively large municipality in Texas purchased a weather contingent power contract for the summer of 2012. This contract paid out in increasing size the hotter the daily maximum temperature (at a defined set of locations) was on weekdays. However, if the daily maximum temperature failed to reach a relatively high and pre-defined level (i.e., "strike level") on a given day, no payout occurred. The formula for the daily payout when hotter than the strike level was a sliding scale in MW (e.g. increasing in XX MW/degree F increments) TIMES 16 (i.e., hours in a day for a peak power transaction) TIMES the non-negative value derived from subtracting a strike level (e.g., $YY/MWH) from the Day Ahead Peak Power Price defined by the Electric Reliability Council of Texas for that municipality's particular region. At the end of the contract period, the daily payouts were summed and paid to the buyer of the option. The contract traded at a steep discount of what the cost would have been of buying the maximum volume of daily power call options in the marketplace to cover the same risk. It offered protection from prices potentially increasing to the regulatory cap on a given day of $4,000 per Mwh that could have cost the municipality tens of millions of dollars if not risk managed in advance.[2]

- A large California municipality transacted a pure rainfall contract that protected against a lack of rainfall for its hydroelectric production over several years. The required payout was defined in $/inch of rainfall below a certain low strike level. In an attempt to eliminate the premium, the municipality offered to pay the risk taker when the water levels were higher than a certain high strike level. The annual potential payout of the contracts executed in the market was in excess of $50 million each year. This contract was executed initially on a single year basis but became one that traded on a multiple year basis. This contract was the first of its kind contract and initially was executed in 1999. Quantos (i.e., variable volume and price combination contracts) were not common when this trade was initially executed. Therefore, the municipality elected to absorb the basis risk between the pure weather market solution and its actual risk. The correlation of modeled risk versus the risk mitigated in the weather contract was very high, however. The municipality ultimately decided the expense of trying to push the market to provide a quanto solution was not a good value proposition at the time. However, by the next year the market responded and provided a weather contingent natural gas price collar structure on a multiple year basis. This structure paid out a fixed volume of natural gas per unit of precipitation above and below a set of strikes

[2] ACES Power (www.acespower.com)

times the price experienced in the natural gas marketplace, with the payment going to the municipality when dry conditions were experienced and to its counterparties when wet conditions were experienced.[3]

- Between 2007 and 2011, a small number of US municipalities executed excess snowfall contracts to offset their snow removal costs in high snowfall years. The entities had modeled their costs for employing snow removal crews on an overtime basis, the additional cost for the diesel deployed to run equipment, and the sand and salt to be applied to the roads beyond their budgeted levels. The popular product at the time was an accumulation of snowfall contract that paid when snowfall accumulations (which were measured at a particular nearby location) surpassed a defined level over a defined period of time for a fixed premium. It is believed the first transaction was originated and executed by a global bank and executed as a derivative. The bank then sold the risk onto the broader weather risk management market. Other transactions were executed directly by reinsurance companies; both in the form of derivatives and insurance.[4]

- A quasi-government group in Europe was subject to a particular union contract that limited the availability of certain construction workers and increased the cost of those that would perform work on winter weekdays based on the temperature experienced at the regional airport (Schiphol Airport, Amsterdam). The financial risk was significant each day cold weather occurred, with the actual monetary amount stepping up considerably at a handful of pre-determined cold temperature levels if measured at specific hours of the morning. The entity budgeted for a maximum number of days of adverse weather as it pursued a range of public works projects, but in order to stay within its budget sought a market alternative to cap any losses from extreme cold. A large European bank originally sourced the transaction in the early 2000's and laid off the risk in the market place, which amounted to several years of contracts with risk transfers of in excess of $100 million per year. This risk index ultimately became a product offering on the CME – the Frost Day Index at Schiphol Airport (Amsterdam).[5]

- Several small Midwest and Northeast US municipalities and quasi-governmental entities have executed contracts with third party snow removal companies that have then hedged their resulting exposure in the weather market. For instance, when a contract is written with a municipality that says that a snow removal company will take care of all snow removal for the municipality for a flat fee of $X per year, a weather related risk has been transferred. The snow removal company typically budgets for a number of snow removal events during the contract. However, if excessive snowfall occurs the third party recognizes that it will actually lose money when it performs under the contract. In order to mitigate this risk, the

[3] WRMA (http://wrma.org/risk_transactions.html)
[4] Axis Re and http://finance.fortune.cnn.com/2014/01/03/wall-street-snow-weather-derivatives/
[5] ABN AMRO and the CME

company purchases high snowfall protection (usually in the form of a customized daily snowfall accumulation or "snowfall events") to cover the average cost of snow removal per defined event above a strike level. Sometimes the purchase of this product is coupled with the sale of a contract which promises the snow removal company's weather derivative counterparty a payment when lower than normal snowfall events occur. This is done to minimize any premium paid and because it relates directly to variable cost savings experienced. Sometimes the net impact to the snow removal company is actually zero; because, a structure (e.g., a collar) is executed which required no premium upfront, the budgeted and acceptable snowfall level is realized, and the lower and higher than normal snowfall event counts which would drive a payment under a third party contract are not.[6]

- In December 2013, the World Bank completed a large weather risk transfer for the country of Uruguay. In drought conditions, Uruguay is exposed to significant damage to its economy (approximately 2% of it GDP is annually at risk) due to poor crop results and higher electricity costs for all customers. The total risk transfer in this weather derivative was approximately $450 million over 18 months. The risk was syndicated to a small number of strongly rated counterparties (Allianz and Swiss Re). The product was purchased by the nation's regulated utility with the assistance of the Ministry of Finance. The government recognized that drought conditions hurt its credit rating and therefore jeopardized its cost of capital in the future. The protection sought was against low rainfall and ultimately low streamflow in the critical river basins the country counts on for its hydroelectric power. The transaction is noteworthy because it is the largest weather mitigation contract executed by a government entity. It also used a very complex set of low streamflow definitions that took the regulated utility's modeled results which converted lake levels from season to season, rainfall amounts at over a dozen locations, and used a series of mathematical formulas to convert these weather variables into expected power generation (or lack thereof). It then converted this loss of hydro power to the quantity of replacement fuel required to generate replacement power from expensive oil based sources. An independent third party was hired to examine the quality of the weather data within the country, to install secondary weather stations in order to provide another set of daily observations, and to monitor ongoing rainfall results to assure Uruguay and the weather risk hedging counterparties a fair settlement would occur.[7]

Most of the executed contracts by municipalities and government entities have been structured as financial derivatives or as physical supply or offtake contracts; but an insurance weather contract with premium paid can serve as an acceptable alternative structure in some circumstances. Most notably, an insurance contract is a superior

[6] JP Morgan.
[7] World Bank (http://treasury.worldbank.org/bdm/pdf/Case_Study/Uruguay_Weather_Derivative.pdf)

alternative when a municipality has the authority to enter into insurance contracts but is prohibited from executing derivative contracts.

Several municipalities have also explored a range of weather derivative options indirectly when it comes to buying wind power and thermally generated replacement power for their hydroelectric facilities when drier than normal conditions persist. Unbeknownst to the municipalities seeking the power supply, a weather risk transfer frequently is sought when the municipality insists that they receive power only under certain weather conditions. This weather trigger then leads that commercial entity that is facing the municipality to either consider self-insurance, imperfect fixed volume commodity hedges that require active management, or to approach the weather risk mitigation market for contracts that more perfectly match their risk profile.

Weather Risk Embedded in Water Service

Weather risk is very significant to municipalities. For the purpose of this white paper, the focus will be directed specifically at municipal and regional systems in the United States responsible for providing water services to their customers.

The Risk Water Suppliers Face

Water risk occurs both on the supply as well as the demand side of the equation for water suppliers. Without water supply to sell, which may come through rainfall, groundwater, snowpack, imported water or other sources, water suppliers are either forced to seek higher cost alternative sources (usually buying water from neighboring regions or drilling into aquifers) or to impose water use restrictions on its customers. Weather risk also impacts water suppliers in periods of extended dryness, where demand for water increases and often results in strains on supply.

Extreme drought can also create other financial risks. In regions of the US such as California, wild fires may occur with greater frequency, and may damage watersheds and drain sources of precious water for firefighting; further exacerbating existing shortages or strained supplies. In addition, these fires may pollute water reserves with ash that must be removed at an additional cost.

Alternatively, a significant weather risk occurs to water suppliers when high rainfall occurs and the anticipated sale of previously budgeted water for irrigation does not occur. Due to the tight budgets many water suppliers currently face, a wet year leading to a drop in water sales can lead to a budget deficit. And if a poor weather pattern persists, two or more years of “bad” weather can severely impact a water supplier’s reputation in the market place and financial position. Its bond rating may be downgraded and/or future bond issuances may be delayed due to higher interest rates associated with the perception of poor financial planning on the part of investors and research analysts.

The water risk for each water supplier varies significantly based on their unique watershed and supply source, the particular contractual terms with customers and potentially with neighboring municipalities that share the same watershed and supply source, and the relationship it has with its regulators. Each water supplier faces its own challenges to balance residential consumption of water with uses such as a cooling source for generating power, agricultural and industrial uses, and recreational uses, while also being good environmental stewards of watersheds.

Current Steps Taken to Manage Weather Risk

Many forms of weather risk mitigation currently exist for water suppliers, but none are perfect. Broadly speaking, these options have attempted to manage weather risk first and foremost through correctly modeling and forecasting for the risk. By incorporating more variables that affect demand, including efficiency and weather patterns, and by incorporating uncertainty through scenario simulation, water supply managers can make more informed decisions regarding costs, revenue requirements and expected sales.

A common method of risk defrayment that is often used is to pass on any costs to consumers through rates. While a market signal in the form of changing price can adjust behavior if presented in a manner that is observable and significant enough to impact behavior, the fact that it can only be done after the fact makes this a tool that has limited physical effectiveness. While the "pass through of cost" mechanism allows municipalities to attempt to capture historical losses, the ability to match losses with appropriate price increases is very complex. Rate increases are often requested after a period of decreased revenue to cover lost resources and to plan for new infrastructure simultaneously. This pairing of required cost factors (actual losses and an infrastructure upgrade) can help deflect some of the backward looking analysis that regulators are prone to take when a budget shortfall occurs.

Water use restrictions represent another form of risk mitigation that typically is one of the last steps taken to manage extreme shortages due to extended periods of drought. Weather-related supply shortages may be addressed by expanding supplies and importing water from a neighboring region, if available, but these supplies may come at a much higher cost due to the source of the supply and infrastructure needed to transport it.

Rainy day funds and rate stabilization funds come in a wide array of structures and are also often utilized to mute weather risk. These can prove effective if they can be built up and truly kept in reserve. These self-insurance funds, however, are an often all-to-accessible source of funding that local politicians can tap for other purposes. Thus this cushion is questionable even if such funds are reserved. Sometimes reserves cannot be built back up in time once drawn down, as weather resources are increasingly becoming volatile and at times poor weather is persistent.

Noting all of the complexities a water supplier faces in maintaining fiscal health, the remaining portion of this white paper will focus on explaining what types of market-based solutions are available to help manage weather-related risk.

Building Blocks for Constructing a Weather Hedge

Weather hedges should be constructed to very closely match the risk an end user encounters. In order to achieve this goal a defined set of steps should be followed.

1) *Determine the Risk Level:* A water supplier's management should be engaged to determine the weather risk faced by the organization. This unique knowledge of a water supplier's weather risk should serve as the launching point for an analysis to more fully determine what type of weather condition leads to a loss or may lead to a loss in the future, and how severe that loss can be. If management feels insulated from weather risk (which usually occurs when the net income volatility due to weather is less than 5%); then it is unlikely that any more work must be done unless conditions are changing and therefore weather risk is expected to increase future volatility in net income. Note, increasing financial leverage, growth in population, and changing usage patterns all are reasons that management should be consistently questioning what impact a significant departure from normal weather patterns may have on their community.

2) *Conduct Further Analysis of Risk:* It is often appropriate for management to establish a team to explore the impact of weather. This team can further investigate at the grass roots level what employees may see as a weather event that leads to extra work for everyone and likely losses for the water supplier. This team can also pull together assumptions, water usage/net revenue models, and results from these models that municipalities use in their annual planning sessions. This can all can be used to help identify the financial impact of changing weather conditions and to help build weather risk mitigation structures that will highly correlate with a municipality's financial results.

3) *Consider Expert Services:* It is frequently worthwhile for a company with little weather risk mitigation skills to hire an outside consultant to assist in the process of verifying the weather related risk, identifying the best weather index to analyze to achieve a possible solution, building a structure that achieves financial goals for management, and assisting in finding the best valued products in the market place from a wide variety of vendors. This specific expertise is typically not present among water supplier managers.

4) *Collect Weather Data:* Weather data related to the perceived risk must be gathered before any quantitative analysis can take place.

    a. Weather data ideally is sourced from an independent provider (e.g., an unbiased source like NOAA) that has sufficiently long records (10 years or more) to test if a current weather event is directly tied to any loss hypotheses. In the interim, if weather data from internal sources is available and that is what employees use for their reference point when they observe weather related losses, then this data is acceptable to use for hypothesis testing. However, if internal weather data proves that a loss is occurring and management elects to eliminate the risk, an alternative source of similar weather data is likely to be demanded by risk takers so that a fair settlement of a contract can be expected. This new data set should correlate well with the internal data set.

5) *Test Weather Event / Loss Hypotheses:* If a weather event can be identified that creates unwanted volatility in net revenues, it should be tested using relatively recent data. If it is proven on a small scale, it frequently makes sense to test using a longer period of time and see if the pattern persists. Using statistical analysis, weather risk can then be related to financial results in order to identify the type of structure that is most ideal. Sometimes, random financial events are muting the weather event's volatility, or conditions have changed and an unfavorable weather event in the future will have a bigger financial shock than ever before. These considerations are part of the necessary analysis.

6) *Identify the Best Weather Structure and Select a Strike:* A weather structure should be crafted to match management's net of any premium position requirements. The Strike in the weather structure is the "pain point" at which management should be willing to pay a modest risk premium to assure itself it does not see a financial result that would be expected under such a weather scenario or even worse weather scenario (without a hedge).

7) *Seek Indicative Pricing from the Derivative Market:* Once the most appropriate instrument is identified (swap, collar, option, or series of options) then it should be sized and indicatively priced to assure that an economic transfer is available. Once pricing comes in, management should determine the value of the proposition.

8) *Ensure Appropriate Documentation is in Place to Allow a Transaction or Consider Changing Formats before Execution:* Before a structure is solidified with outside risk takers, the municipality must ensure that it has the charter to execute such a transaction and has appropriate documentation set with its expected counterparty(s). If not, it is imperative to establish such governing documentation or formulate a better structure (e.g., insurance or bond issuance) that is more suitable.

In summary, a weather contract will need the following items identified for a contract to then be constructed. Definitions of terms may be found in **Appendix 1**.

SAMPLE TERM SHEET FOR A DERIVATIVE:

Instrument: Swap, Option, or Collar
Weather Index: TBD – rainfall inches, rain days (customized), streamflow, etc.
Term: Start Date – End Date for weather measurements to be observed
Weather Measurement Location: TBD
Weather Data Provider: TBD – but usually a third party that is unbiased
Buyer: TBD
Seller: TBD
Strike: TBD – the "pain point" that management wants to avoid experiencing
Notional Amount: $ payment per weather events beyond Strike
Contractual Limit (offered by the Buyer): TBD – not required
Contractual Limit (offered by the Seller): TBD – not required
Settlement Value: TBD – calculated per formula
Premium: TBD – mutually agreed
Collateral Obligations Imposed by the Buyer: TBD – imposed to make sure payment is made even by defaulting entity; negotiable
Collateral Obligations Imposed by the Seller: TBD – if full premium is paid upfront then $0, otherwise negotiable

Note: A weather insurance policy would have many of the same terms of a derivative contract except that the entity buying the policy must pay a premium, must be indemnifying a definable loss, and must go through an arduous claims process to receive a payment as spelled out in the insurance policy.

ADDITIONAL TERMS:

Exercise Method: Manual or automatic – for ease and to match market convention insist on automatic
Settlement Agent: TBD – the one that presents the financial results to the other party
Calculation Agent: TBD – calculates all values for formula payout
Premium Payment Date: TBD – if applicable, but usually one to three days after transaction is agreed and usually paid by wire
Settlement Payment Date: TBD but usually 3-14 days after the Term
Eligible Contract Participants: Both Buyer and Seller must be sophisticated investors
Dispute Resolution Methodology: TBD – usually arbitration with risk management professionals presiding – rarely needed
Rounding Methodology: TBD
Fallback Methodology: TBD – relevant to protect against lost weather stations from some catastrophic event – usually choosing a nearby station and making some adjustments to weather measurement values based on historical bias
ISDA Documentation: Weather contracts are a standard derivative contract with its own definitions defined by ISDA
Risk Premium: Depends on instrument chosen – usually a mark-up over what would be deemed a 50/50 transaction
Second Settlements: TBD – likely not required unless data source chosen might change readings after their Settlement Payment Date

Considerations for Pursuing an Optimal Weather Hedge

With the basics of weather contracts understood, the next step is to seek a contract with good value from the market. Various points should be considered in order to get the best contract from the market.

Liquidity is the first driver to be considered when pursuing a market-based solution. Liquidity is a measurement of the number of players in the market willing to trade such a Weather Index. The more potential counterparties there are for a risk transfer, generally, the better pricing that is achieved due to competition. Because a water supplier will likely seek a precipitation index of some sort, this is both a positive and a negative for liquidity. Some hedge funds will shy away from the risk due to the lack of a trading index on the CME for such a risk transfer. Others will flock to it as it is providing them a risk type that is required to meet their mandates for diversification specified in their fund's charter. Reinsurance companies will be indifferent to the risk, as they generally are risk absorbers with less interest in later trading a bespoke structure. Each reinsurance company has its own risk premium weightings for each type of weather risk it analyzes (water risk premiums should be generally in line with those for temperature). Reinsurance companies are also constrained by their own risk appetite that can easily be met by competing transactions. Therefore, one reinsurance company is rarely the best priced for all weather transactions because their capacity is naturally constrained. Through time reinsurance companies may look to hedge with a standard weather transaction (e.g. temperature index like CDD) and take on the correlation risk between mild temperatures and rainfall, but initially it is more common for the reinsurance companies to look to write more risk in order to diversify their book vs. outright sell down positions. That said, retro-insurance, which is the common method of risk transfer between reinsurers, does provide reinsurance companies a mechanism to share risk with others in the reinsurance industry. Banks, in contrast, will typically look inside their own risk books to seek a natural offset for a weather risk and then look to outside players in the market place to syndicate a hedging transaction's risk. Frequently, banks have a wider universe of risk takers at their disposal than reinsurance companies that are balkanized. Therefore, for large structured transactions, banks can potentially be the best counterparty for a weather hedge.

Size of Requested Trade should be considered and matched to each liquidity provider's risk appetite. A typical bespoke trade in the weather market seeks to transfer between $100k-75 million (per season or year). This size risk packet can easily be worked in the market and competition will ensue. The market will typically yield itself to larger transactions as well. A $100-300 million maximum risk transfer in one year is very achievable, especially if the risk transfer is an option with a 25% or less chance of seeing its strike exceeded. The amount of capacity will tend to increase with a lower probability of occurrence. A transaction with swaps on the other hand may be limited to $25-100 million of well-priced capacity per year. If a market transaction being sought is for even greater capacity, it may behoove the hedger to spread its hedge execution activity through time in order to allow the market to absorb and ultimately spread the risk. Finally, smaller trades are possible (e.g. standardized CME contracts typically trade in lot sizes that equate to $20k of a risk transfer) but typically they require a simpler and precise structure to be brought to market to entice third parties to work on the transaction.

The Weather Forecast is something that needs to be considered when a hedge is being pursued. Weather forecasts are notoriously wrong far in advance of the time period for which they are prepared. Temperature forecasts are usually more accurate than precipitation forecasts. Typically 3-9 months out, the weather market will put some credence in the forecasts. In fact for precipitation, outside of one month out, the dominant driver in most meteorologists' models will be the ENSO cycle forecast (i.e., the measurement of subsurface water temperatures in the Pacific Ocean). ENSO forecasts are very significant for winter precipitation in the southern tier of the US. Even when a dominant signal is not evident, a particular ENSO forecast will tend to bias a meteorologist's forecast for precipitation. If a weather risk shedding entity can catch a forecast that makes the risk profile of their proposed hedge be one that looks less likely to occur, one can usually find the weather market offering a bit of a discount in its pricing. However, if the forecast is against someone seeking a hedge and the risk period is still 4-9 months out, it may behoove the hedger to wait to the 3 month mark before the risk period begins and see if the forecast changes. Regardless, it should be understood that the market will typically fully price in any negative forecast irrespective of its likelihood of accuracy. Note, once forecasts get inside of 3 months it has generally proven out that the forecast bias in the marketplace has a tendency to persist up until the risk period actually commences. Therefore, it is less likely a hedging entity can be successful and capture an improvement in price once a party is within 3 months of their desired Term. In fact, more often than not, the forecast inside of 3 months generally has a tendency to stay neutral or go against a proposed structure. This can wreak havoc on first time buyers that are typically struggling to fully get buy-in from its decision makers, because a volatile and negative move in the forecast translates into a constantly moving price that often makes the proposed trade more expensive. To be clear, even if a forecast makes a risk transfer more expensive, it does not mean the risk transfer should be avoided. The price the market offers is the price; the hedging entity must then assess the impact the weather event will have on it if left unhedged. Clearly the best time to hedge is far ahead of the risk period, especially if the weather market is accepting a favorable forecast that still will experience significant volatility even prior to the Term of any proposed transaction.

Single Risk Period vs. Multiple Year Transactions is a structuring consideration to help an end user match its risk transfer profile with the historical weather patterns. By buying a multi-year structure, the water supplier is seeking protection against persistence that may be exactly what is required. A buyer can modify its structure and put a contractual maximum in place that is less than summing multiple, single year transactions together. In doing so, the overall cost is less than buying the multiple options with a larger overall limit. The true benefit of a multi-risk period structure is it minimizes future cost increases that can occur with single risk period structures. Specifically, if executed in single risk period format and the first risk period of a hedging program goes against the risk absorbing counterparties, the cost of subsequent risk transfers will be more costly due to this recent loss. In contrast, if no loss occurs the first period of a risk transfer period, generally a subsequent transaction rarely receives a markedly improved price. However, contracting on a multi-year basis may not be ideal if a regulatory change is expected that will change the risk profile in the future. A longer term risk transfer might then be a mismatch for that entity's risk profile.

Current Market Events may allow a water supplier to get improved pricing or possibly worse pricing. If a water supplier is fortunate to seek a hedge when a similar but offsetting risk transaction by another hedger is occurring, pricing should improve as those in the market are getting more balanced books as a result of both transactions occurring in concert with one another. Skilled structuring agents should be able to help a water supplier get its best fill by identifying offsetting risks that might transact in the market place. Note, in contrast, if multiple entities with similar risk profiles seek a hedge simultaneously, and the market knows both transactions are likely, the pricing in the market will likely deteriorate for both or at least for the second party that executes in the marketplace.

Credit Quality of a counterparty in a hedge transaction should be important to a municipality. Most reinsurance companies and banks offer strong balance sheets and pose a low risk for a municipality to not be paid if a payment is required from its contract. Hedge funds, however, frequently are weaker credits. Due to the fact banks typically face these hedge funds and reinsurance companies for other trades gives banks an advantage in harnessing market capacity and then passing on such capacity in the form of single bilateral trade between the bank and the municipality. However, in light of current regulatory changes (the enforcement of the Volcker Rule and Dodd Frank legislation) it should be noted that a bank's traditionally superior position to effectively aggregate risk capacity and disperse an end user's risk into the market may be nullified. Only time will tell how banks react to these rules that as of December 2013, have forced JP Morgan, Deutsche Bank, and Morgan Stanley to pare back their exposure to commodity risk management. While it may be tempting to seek multiple counterparties to gain diversification in counterparties, the complicating fact that risk takers frequently check their own marks on a potential position with others in the market place often leads to a higher transaction costs due to the market's incorrect perception that many trades are available. It also means negotiating multiple sets of credit documents with multiple counterparties, which for a first time trade, may be a bit taxing for a water supplier. A skilled structuring professional should be able to help navigate the market and achieve the most optimal execution method (i.e., identifying the best number and composition of counterparties to approach).

Net Positive Premium Derivative Structures can be considered, but are typically for more sophisticated traders since the chance of loss of being net short options could be frowned upon by regulators due to the degree of loss that is possible. But once comfortable with weather structures and how they match up to a water supplier's existing operations and rate structures, the ability to sell options (on a net basis) and to collect a premium may be deemed a desirable means of managing risk since it allows revenue that is usually only hoped for to be partially realized every year through the premium payment to the water supplier. If there is confidence that the underlying business will generate excess returns in certain possible weather scenarios, this structure that sells those scenarios to the market can regularly bring in incremental dollars that would only be received on an irregular basis. A very important structural provision to consider in the sale of a water supplier's upside via derivative contracts is that any potential loss can be capped with a maximum loss clause to keep any losses to a pre-defined and acceptable level that regulators and risk managers can agree to in advance. If structured appropriately, the loss in the derivative contract should be equal to or less than the positive and essentially certain net revenue that comes from the water supplier's underlying business. It is very likely that there are legal and regulatory restrictions that a municipality must adhere to when completing a net positive premium structure.

Pricing Basics for a Weather Hedge

The derivative and insurance markets value weather contracts in a very similar manner, but it should be noted that the disparity in pricing of a bespoke contract can be significant between two similar entities on a given day. Standardized products of modest size typically trade in a relatively tight range of each other (e.g. usually within 5% of each other). Therefore, receiving pricing from at least two or three entities on a bespoke structure should be pursued to assure the counterparty selected is supplying a reasonably valued service. The offset to this requirement for price checking is one should not want to excite the market to the point that pricing fatigue sets in for those pricing the contract (i.e., the pricing requests go on and on for several months or even years which makes dealers get sloppy with providing their best and tightest pricing) or the relatively modest size weather market can begin to perceive the amount of capacity being demanded is larger than it is, which would lead to an increased risk premium being demanded by the market. Risk taking entities are typically rewarded for the work supplied in the process. Normally those that help structure a solution are allowed a better price or at least granted the right to match the price of a competitor than those that simply price a structure. This is done in order to facilitate future value added solutions being created. In addition, most hedging entities take into account the credit quality, the form of contract (insurance vs. derivative) and other services provided (credit lines or other insurance products) by the entity they are considering for their hedging business.

Simply, both the insurance and derivative markets will look to a proposed contract's specific terms and perform a historical analysis on how the contract would have paid out in each year in history. Each entity will start with relatively simple historical views using data as it was reported by the Weather Data Provider. A pricing professional then will subjectively use the length of the historical data and associated outcomes to calculate an average outcome and a standard deviation of the outcome gross payment scenarios. Once these values are calculated, the pricing professional will use other pricing parameters to determine a price. These additional parameters include:

- identifying any observable markets deemed to be comparable
- a view of how this newly priced contract brings diversification or concentration to an existing or expected book of business
- any pre-defined pricing parameters set by the head of trading or underwriting to allow for an expected level of profitability per trade (i.e., a defined minimum risk premium is imposed)
- any weather forecasts

A higher risk premium may also be imposed for the quality of the historical weather data that is observed (e.g., more gaps in the data's time series require synthetic fixing of observations using neighboring weather stations) and if a weather observation entity is deemed risky (e.g. low quality data from a relatively poor country's meteorological office that may have a tendency to skip on weather station maintenance). While there are no absolutes, premiums paid generally are 5% to 35% of a standard deviation over historical average payouts. Strikes for swaps and the midpoint on premium free collars are typically within 1-4% of the historical average. Pricing may deviate from these levels and in rare instances may even be priced below historical average payouts due to the factors above.

Insurance companies will have a tendency to push for structures to be changed to be much more premium-heavy due to their specific requirement that their policies underwritten must involve a premium. Also, due to the fact many insurance companies enjoy underwriting policies for extremely low probability loss events, it is common for insurance companies to impose a greater risk premium for selling insurance contracts that have a Strike closer to the observed historical average. Many insurance companies like writing contracts with a probability of any loss being less than 25%. Finally, insurance companies will insist on some level of Contractual Cap (i.e. a maximum the insurance policy buyer can collect to offset its loss). Derivative dealers will tend to price all options, swaps, and collars with relative indifference whether there is a Contractual Cap or not.

In some instances, the pricing entity will manipulate the historical data set to impose their own perception of what the historical data distribution should be in light of current climate dynamics. This data substitution methodology has been most noticeably seen in temperature-based contracts where statistical means are used to "detrend" historical distributions in order to establish a more consistent looking data set. In the last 25 years with temperature conditions having been volatile (but frequently observed to have been warming), many in the industry will adjust longer records to be more in line with the last 25 years. Rainfall and wind, however, typically have displayed less continuous trending and therefore most pricing entities will focus on the longest observable historical (no detrending or substitution of data) record to come up with historical average outcomes and standard deviations.

In all instances, the consistent reporting of weather data should be considered by a hedging entity. This typically means that a quick check should occur to review a station's record for any "discontinuities". These can be thought of as a check to assure that a weather station has reported more or less consistently through the years. It is desirable that instrumentation be as consistent as possible and stations are maintained with regularity. While some discontinuities have been observed with temperature readings, quality weather observers (e.g. NOAA) will work very hard to prevent any discontinuities from happening. Most discontinuities, while relatively rare and largely immaterial, have occurred in temperature. A weather structuring professional can offer a quick historical analysis to flag a weather station for discontinuities in the historical weather observations.

Finally, insurance companies will charge a risk premium to cover the cost of governance by its local (usually state) regulator. This pass-through cost typically adds approximately 5% (varies by state in US) to any risk premium in an insurance contract.

SAMPLE PRICING:

This section explores how weather derivatives are priced from raw weather data, without any discernible bias for forecasts, liquidity premiums, etc.

Assume the following rainfall history exists (i.e. 24 year history of cumulative rainfall measurements at a particular Location), and that an End User wants to engage in a weather derivative transaction to mitigate its risk. For the purposes of this example, we will price out the following products using the pricing parameters this market typically uses (keeping in mind that other factors like forecasts and other transactions in the market place may make the price either cheaper or more expensive). Gross payouts and net payout frequency shall be calculated as well.

- a call and put option,
- a swap (being bought and sold),
- a collar (being bought and sold)

CUMULATIVE RAINFALL MEASURED FROM JAN-DEC EACH YEAR
LOCATION: SAME EACH YEAR

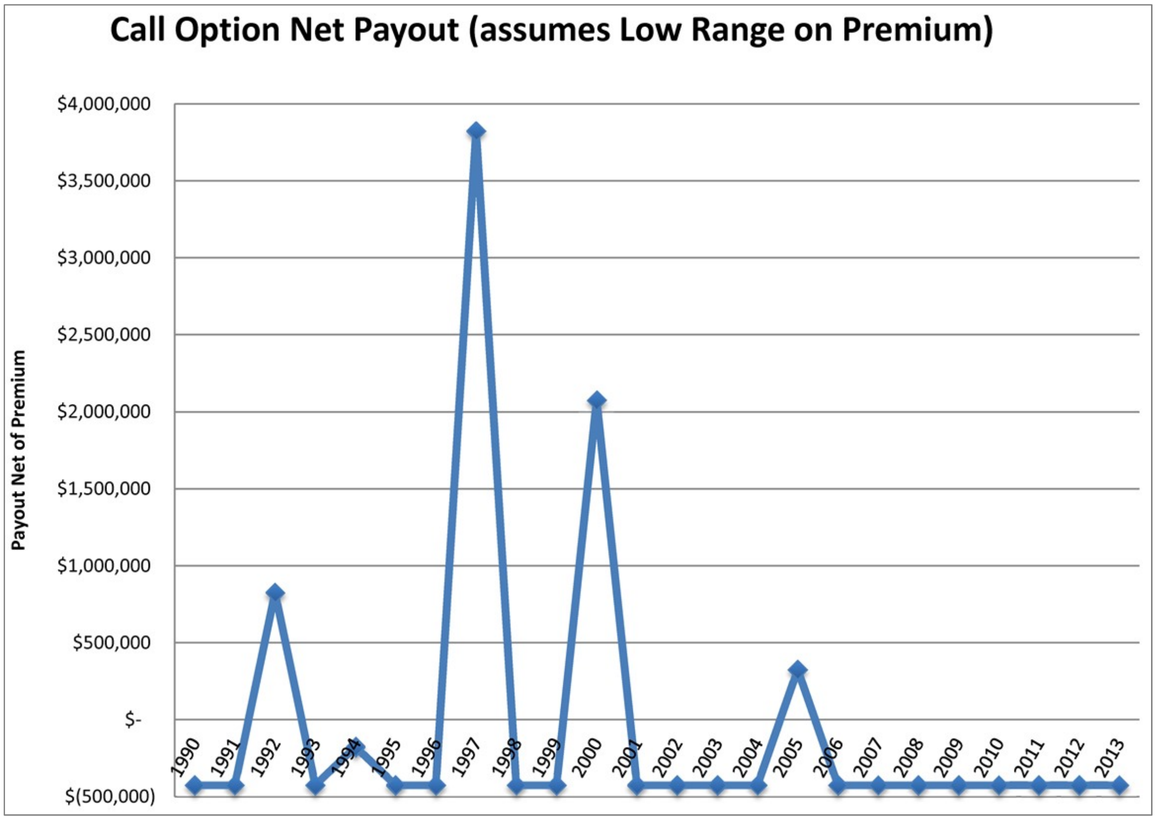
YEAR	INCHES OF RAINFALL	HISTORICAL AVERAGE
1990	20	49.0
1991	46	
1992	70	
1993	34	
1994	66	STANDARD DEVIATION
1995	56	17.4
1996	29	
1997	82	
1998	59	
1999	48	MINIMUM
2000	75	20
2001	22	
2002	48	
2003	58	
2004	33	MAXIMUM
2005	68	82
2006	65	
2007	35	
2008	40	
2009	46	
2010	65	
2011	42	
2012	45	
2013	25	

Note in all structural examples below a reference is made to a Contractual Cap relative to historical payouts. While no Contractual Cap is required by most derivative market participants (insurance / reinsurance companies being the exception), it sometimes makes sense for an End User to put a cap on a transaction so that some premium dollars paid for protection are saved on an option or to limit its downside in a swap or collar to a more manageable dollar amount.

CALL OPTION:
Instrument: Call option on Cumulative Rainfall (hedges End User against high rainfall)
Weather Index: Cumulative Rainfall at Location Z
Buyer: End User
Term: January-December 20XX
Strike: 65 inches
Notional: $250k per inch of rainfall
Contractual Cap: Optional
Range of Expected Premium: $425,136 (LOW END) or $725,950 (HIGH END)
Maximum Potential Gain to End User: Unlimited (Note, 24 year historical maximum is $4,250,000)
Maximum Potential Loss to End User: Premium Paid

CALL OPTION PRICING
STRIKE = 65
NOTIONAL $250,000 per inch

YEAR	INCHES (OF RAINFALL)	GROSS PAYOUT = (INCHES - STRIKE) * $250K	AVG GROSS PAYOUT	
1990	20	$0		$375,000
1991	46	$0		
1992	70	$1,250,000		
1993	34	$0	STD DEVIATION OF GROSS PAYOUT	
1994	66	$250,000		$1,002,714
1995	56	$0		
1996	29	$0		
1997	82	$4,250,000	5% STD DEVIATION OF GROSS PAYOUT	
1998	59	$0		$50,136
1999	48	$0		
2000	75	$2,500,000		
2001	22	$0	35% STD DEVIATION OF GROSS PAYOUT	
2002	48	$0		$350,950
2003	58	$0		
2004	33	$0		
2005	68	$750,000	EXPECTED PREMIUM (LOW RANGE)	
2006	65	$0	5% STD DEV + AVG GROSS	
2007	35	$0		$425,136
2008	40	$0	NET PAYOUT FREQUENCY	4/24 years
2009	46	$0		
2010	65	$0	EXPECTED PREMIUM (HIGH RANGE)	
2011	42	$0	35% STD DEV + AVG GROSS	
2012	45	$0		$725,950
2013	25	$0	NET PAYOUT FREQUENCY	4/24 years



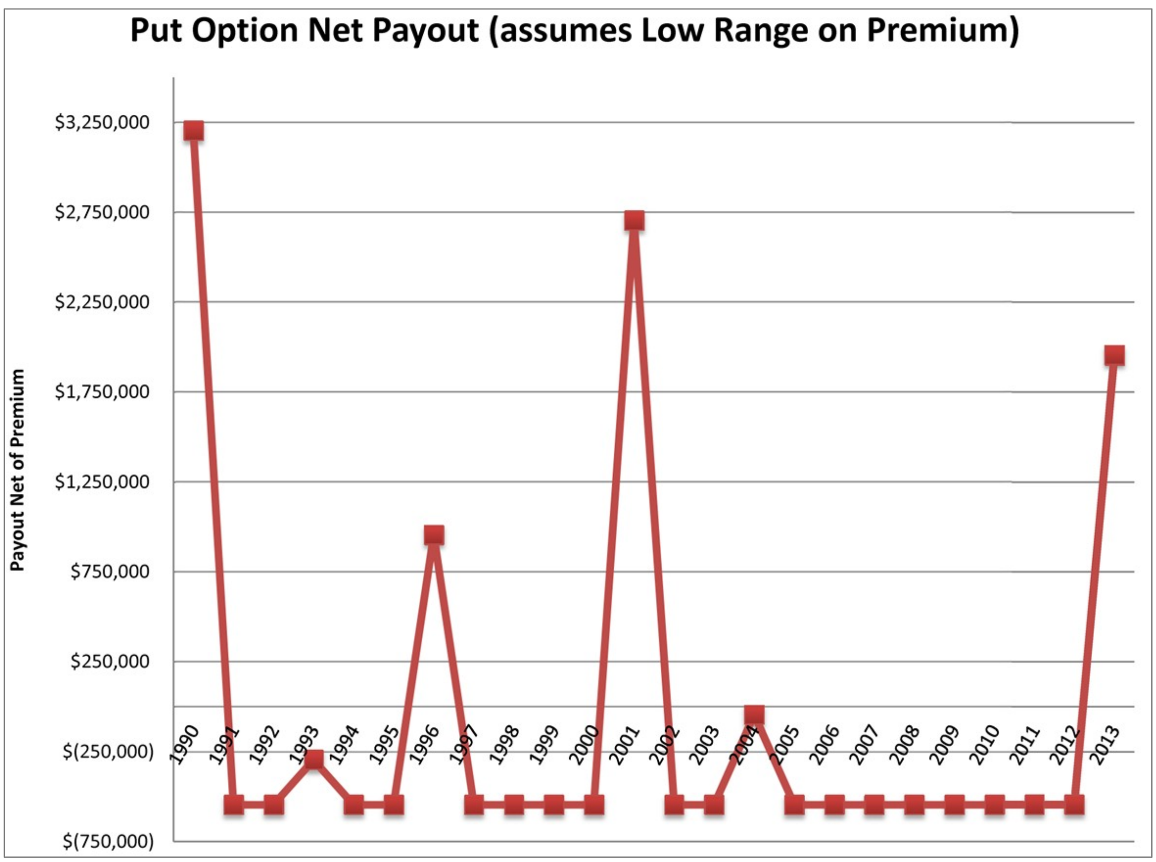
PUT OPTION:
Instrument: Put option on Cumulative Rainfall (hedges End User against low rainfall)
Weather Index: Cumulative Rainfall at Location Z
Buyer: End User
Term: January-December 20XX
Strike: 35 inches
Notional: $250k per inch of rainfall
Contractual Cap: Unlimited
Range of Expected Premium: $544,440 (LOW END) or $873,578 (HIGH END)
Maximum Potential Gain to End User: Best case scenario occurs at 0 rainfall and therefore $8,750,000 (Note, 24 year historical maximum is $3,750,000)
Maximum Potential Loss to End User: Premium Paid

PUT OPTION PRICING

STRIKE = 35

NOTIONAL $ 250,000 per inch

YEAR	INCHES (OF RAINFALL)	GROSS PAYOUT = (STRIKE - INCHES) * $250K	AVG GROSS PAYOUT	
1990	20	$3,750,000		$489,583
1991	46	$0		
1992	70	$0		
1993	34	$250,000	STD DEVIATION OF GROSS PAYOUT	
1994	66	$0		$1,097,129
1995	56	$0		
1996	29	$1,500,000		
1997	82	$0	5% STD DEVIATION OF GROSS PAYOUT	
1998	59	$0		$54,856
1999	48	$0		
2000	75	$0		
2001	22	$3,250,000	35% STD DEVIATION OF GROSS PAYOUT	
2002	48	$0		$383,995
2003	58	$0		
2004	33	$500,000		
2005	68	$0	EXPECTED PREMIUM (LOW RANGE)	
2006	65	$0	5% STD DEV + AVG GROSS	
2007	35	$0		$544,440
2008	40	$0	NET PAYOUT FREQUENCY	4/24 years
2009	46	$0		
2010	65	$0	EXPECTED PREMIUM (HIGH RANGE)	
2011	42	$0	35% STD DEV + AVG GROSS	
2012	45	$0		$873,578
2013	25	$2,500,000	NET PAYOUT FREQUENCY	4/24 years

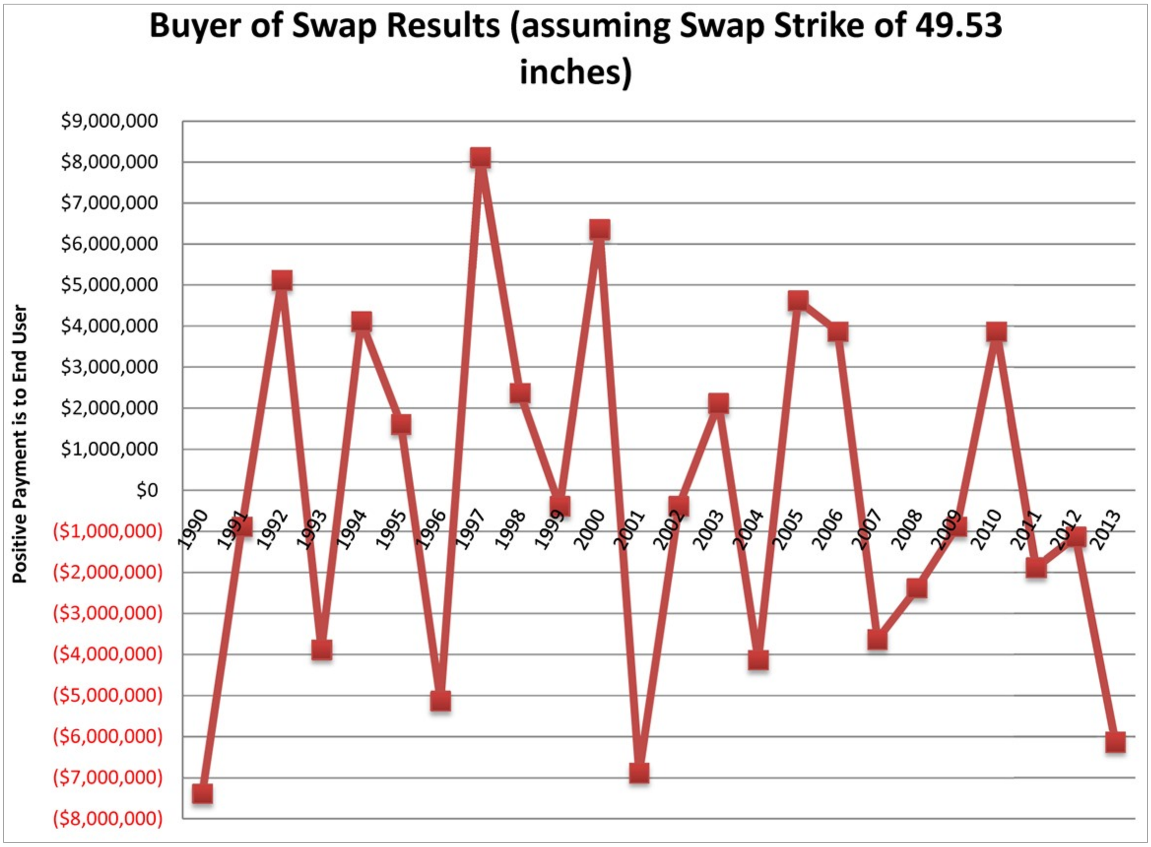


In contrast if a swap is being priced on the same time series of weather data, the Swap Strike executed would likely be between 49.53 and 51.00 inches if the swap is purchased by an End User and between 47.08 and 48.55 inches if the swap is sold by the End User.

SWAP:
Instrument: Swap on Cumulative Rainfall (hedges End User against high rainfall)
Weather Index: Cumulative Rainfall at Location Z
Term: January-December 20XX
Buyer: End User (will receive payment above the Swap's Strike and pay out below the Swap's Strike)
Swap Strike: TBD (see below)
Notional: $250k per inch of rainfall
Contractual Cap: Optional
Premium Paid: None
Maximum Potential Gain to End User: Unlimited, unless capped. Note, 24 year historical maximum is $8,117,500 (w/ 49.53 Swap Strike) and $7,750,000 (w/ 51.00 Swap Strike)
Maximum Potential Loss to End User: Worst case occurs at zero rainfall (unless capped) and yields a $12,382,500 loss (w/ 49.53 Swap Strike) and $12,750,000 (w/ 51.00 Swap Strike); however, note the 24 year historical maximum is $7,382,500 (w/ 49.53 Swap Strike) and $7,750,000 (w/ 51.00 Swap Strike)

SWAP PRICING (END USER BUYING)
SWAP STRIKE = TBD
NOTIONAL $ 250,000 per inch

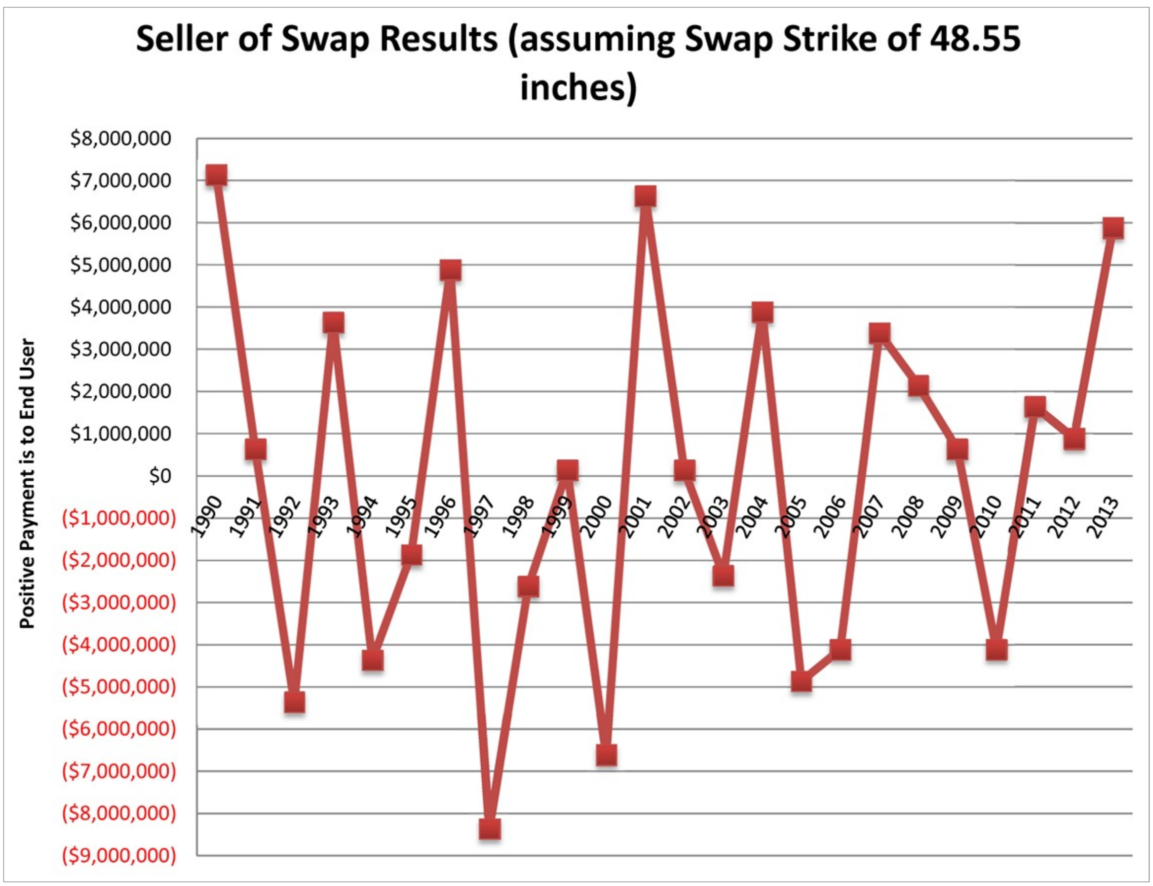
YEAR	INCHES OF RAINFALL	SWAP STRIKE DETERMINATION AVERAGE RAINFALL	NET PAYOUT BEST EXPECTED SWAP STRIKE (49.53)	NET PAYOUT WORST EXPECTED SWAP STRIKE (51.00)
1990	20	49.04	($7,382,500)	($7,750,000)
1991	46		($882,500)	($1,250,000)
1992	70	1% of AVERAGE RAINFALL	$5,117,500	$4,750,000
1993	34	0.49	($3,882,500)	($4,250,000)
1994	66		$4,117,500	$3,750,000
1995	56		$1,617,500	$1,250,000
1996	29	4% of AVERAGE RAINFALL	($5,132,500)	($5,500,000)
1997	82	1.96	$8,117,500	$7,750,000
1998	59		$2,367,500	$2,000,000
1999	48		($382,500)	($750,000)
2000	75	BEST EXPECTED SWAP STRIKE (1%)	$6,367,500	$6,000,000
2001	22	49.53	($6,882,500)	($7,250,000)
2002	48		($382,500)	($750,000)
2003	58		$2,117,500	$1,750,000
2004	33	WORST EXPECTED SWAP STRIKE (4%)	($4,132,500)	($4,500,000)
2005	68	51.00	$4,617,500	$4,250,000
2006	65		$3,867,500	$3,500,000
2007	35		($3,632,500)	($4,000,000)
2008	40		($2,382,500)	($2,750,000)
2009	46		($882,500)	($1,250,000)
2010	65		$3,867,500	$3,500,000
2011	42		($1,882,500)	($2,250,000)
2012	45		($1,132,500)	($1,500,000)
2013	25		($6,132,500)	($6,500,000)
		AVERAGE PAYOUT (+ IS NET TO END USER)	($122,083)	($489,583)
		FREQUENCY OF (+) NET PAYOUT	10/24	10/24
		MAXIMUM GAIN TO END USER	$8,117,500	$7,750,000
		MAXIMUM LOSS TO END USER	$7,382,500	$7,750,000



Instrument: Swap on Cumulative Rainfall (hedges End User against low rainfall)
Weather Index: Cumulative Rainfall at Location Z
Term: January-December 20XX
Seller: End User (will receive payment below the Swap's Strike and pay out above the Swap's Strike)
Swap Strike: TBD
Notional: $250k per inch of rainfall
Contractual Cap: Optional
Premium Paid: None
Maximum Potential Gain to End User: Best possible case is zero rainfall (unless capped) which yields $12,137,500 (w/48.55 Swap Strike) and $11,770,000 (w/ 47.08 Swap Strike) however, note the 24 year historical maximum is $7,137,500 (w/ 48.55 Swap Strike) and $6,770,000 (w/ 47.08 Swap Strike)
Maximum Potential Loss to End User: Unlimited, unless capped. Note, 24 year historical maximum is $8,362,500 (w/ 48.55 Swap Strike) and $8,730,000 (w/ 47.08 Swap Strike)

SWAP PRICING (END USER SELLING)
SWAP STRIKE = TBD
NOTIONAL $ 250,000 per inch

YEAR	INCHES OF RAINFALL	SWAP STRIKE DETERMINATION AVERAGE RAINFALL	NET PAYOUT BEST EXPECTED SWAP STRIKE (48.55)	NET PAYOUT WORST EXPECTED SWAP STRIKE (47.08)
1990	20	49.04	$7,137,500	$6,770,000
1991	46		$637,500	$270,000
1992	70	1% of AVERAGE RAINFALL	($5,362,500)	($5,730,000)
1993	34	0.49	$3,637,500	$3,270,000
1994	66		($4,362,500)	($4,730,000)
1995	56		($1,862,500)	($2,230,000)
1996	29	4% of AVERAGE RAINFALL	$4,887,500	$4,520,000
1997	82	1.96	($8,362,500)	($8,730,000)
1998	59		($2,612,500)	($2,980,000)
1999	48		$137,500	($230,000)
2000	75	BEST EXPECTED SWAP STRIKE (1%)	($6,612,500)	($6,980,000)
2001	22	48.55	$6,637,500	$6,270,000
2002	48		$137,500	($230,000)
2003	58		($2,362,500)	($2,730,000)
2004	33	WORST EXPECTED SWAP STRIKE (4%)	$3,887,500	$3,520,000
2005	68	47.08	($4,862,500)	($5,230,000)
2006	65		($4,112,500)	($4,480,000)
2007	35		$3,387,500	$3,020,000
2008	40		$2,137,500	$1,770,000
2009	46		$637,500	$270,000
2010	65		($4,112,500)	($4,480,000)
2011	42		$1,637,500	$1,270,000
2012	45		$887,500	$520,000
2013	25		$5,887,500	$5,520,000
		AVERAGE PAYOUT (+ IS NET TO END USER)	($122,917)	($490,417)
		FREQUENCY OF (+) NET PAYOUT	14/24	12/24
		MAXIMUM GAIN TO END USER	$7,137,500	$6,770,000
		MAXIMUM LOSS TO END USER	$8,362,500	$8,730,000



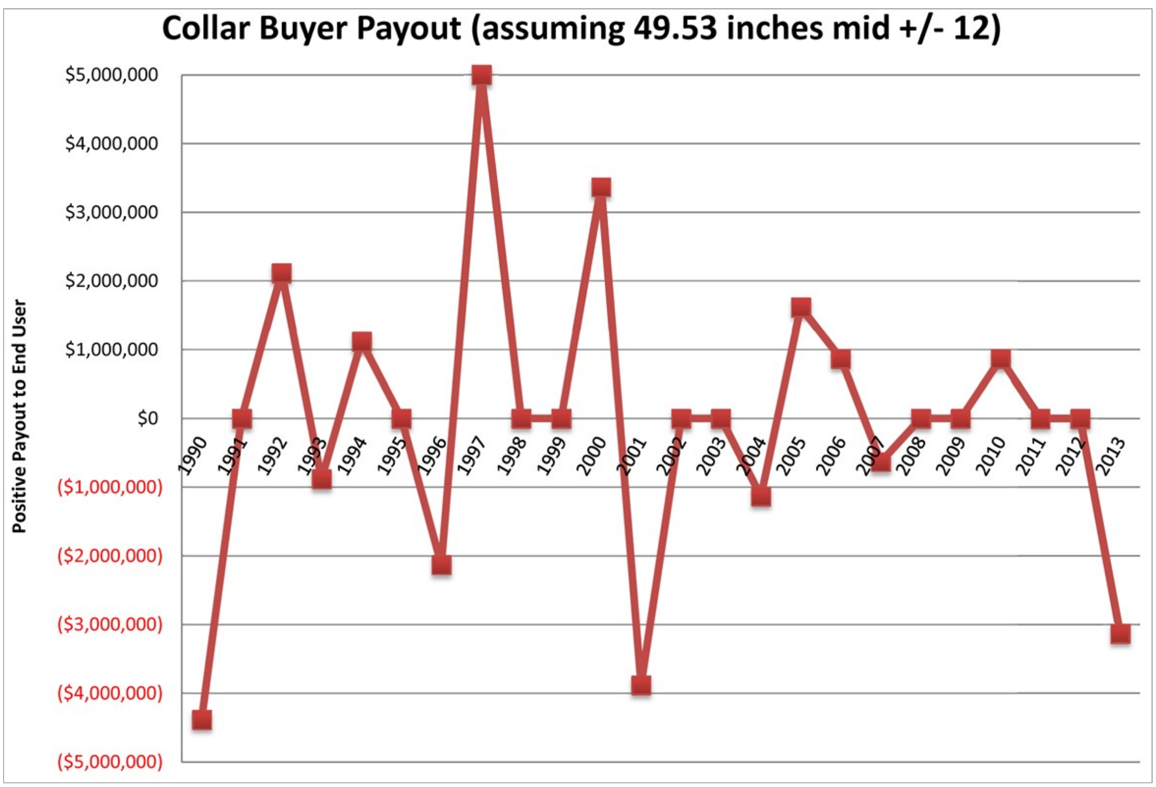
The market maker will choose the strike level the hedging party receives, and if the market maker is buying the swap will typically bid below the historical average and if selling the swap typically will offer above the historical average. By moving the strike around on the swap the market maker is able to provide the risk mitigation structure with no premium but at a level it expects to receive an acceptable return on average for the risk taken. Note that the hedging party is obligating itself to pay out on a leg of the swap it elects to sell (possibly up to a cap or unlimited if desired).

If the same terms are considered, but a collar (i.e. a call and a put option with dissimilar Strikes) is being priced, the Strike of the swap would typically serve as the mid-point for a collar structure. The put and call option strikes then would usually be set equidistant around the swap's strike. Again, the swap level which will serve as the mid-point depends on if the market maker is being asked to buy the collar (long the call option and short the put option) or vice versa.

COLLAR:
Instrument: Swap on Cumulative Rainfall (hedges End User against high rainfall)
Weather Index: Cumulative Rainfall at Location Z
Term: January-December 20XX
Buyer: End User (will receive payment above the Call Option Strike and pay out below Put Option Strike)
Call Option Strike: A inches above Swap Strikes above when End User is Buyer of swap
Put Option Strike: A inches below Swap Strikes above when End User is Buyer of swap
Notional: $250k per inch of rainfall
Contractual Cap: Optional, but assumed to be $5 million
Premium Paid: None
Maximum Potential Gain to End User: $5 million
Maximum Potential Loss to End User: $5 million

COLLAR PRICING (END USER BUYING)
UPPER STRIKE = 12 ABOVE SWAP STRIKE
LOWER STRIKE = 12 BELOW SWAP STRIKE
NOTIONAL $ 250,000 per inch

YEAR	INCHES OF RAINFALL	SWAP STRIKE DETERMINATION AVERAGE RAINFALL	NET PAYOUT BEST EXPECTED COLLAR +/- 12 (AROUND 49.53)	NET PAYOUT WORST EXPECTED COLLAR +/12 (AROUND 51.00)
1990	20	49.04	($4,382,500)	($4,750,000)
1991	46		$0	$0
1992	70	1% of AVERAGE RAINFALL	$2,117,500	$1,750,000
1993	34	0.49	($882,500)	($1,250,000)
1994	66		$1,117,500	$750,000
1995	56		$0	$0
1996	29	4% of AVERAGE RAINFALL	($2,132,500)	($2,500,000)
1997	82	1.96	$5,000,000	$4,750,000
1998	59		$0	$0
1999	48		$0	$0
2000	75	BEST EXPECTED SWAP STRIKE (1%)	$3,367,500	$3,000,000
2001	22	49.53	($3,882,500)	($4,250,000)
2002	48		$0	$0
2003	58		$0	$0
2004	33	WORST EXPECTED SWAP STRIKE (4%)	($1,132,500)	($1,500,000)
2005	68	51.00	$1,617,500	$1,250,000
2006	65		$867,500	$500,000
2007	35		($632,500)	($1,000,000)
2008	40		$0	$0
2009	46		$0	$0
2010	65		$867,500	$500,000
2011	42		$0	$0
2012	45		$0	$0
2013	25		($3,132,500)	($3,500,000)
		AVERAGE PAYOUT (+ IS NET TO END USER)	($50,938)	($260,417)
		FREQUENCY OF (+) NET PAYOUT	7/24	7/24
		MAXIMUM GAIN TO END USER	$5,000,000	$4,750,000
		MAXIMUM LOSS TO END USER	$4,382,500	$4,750,000

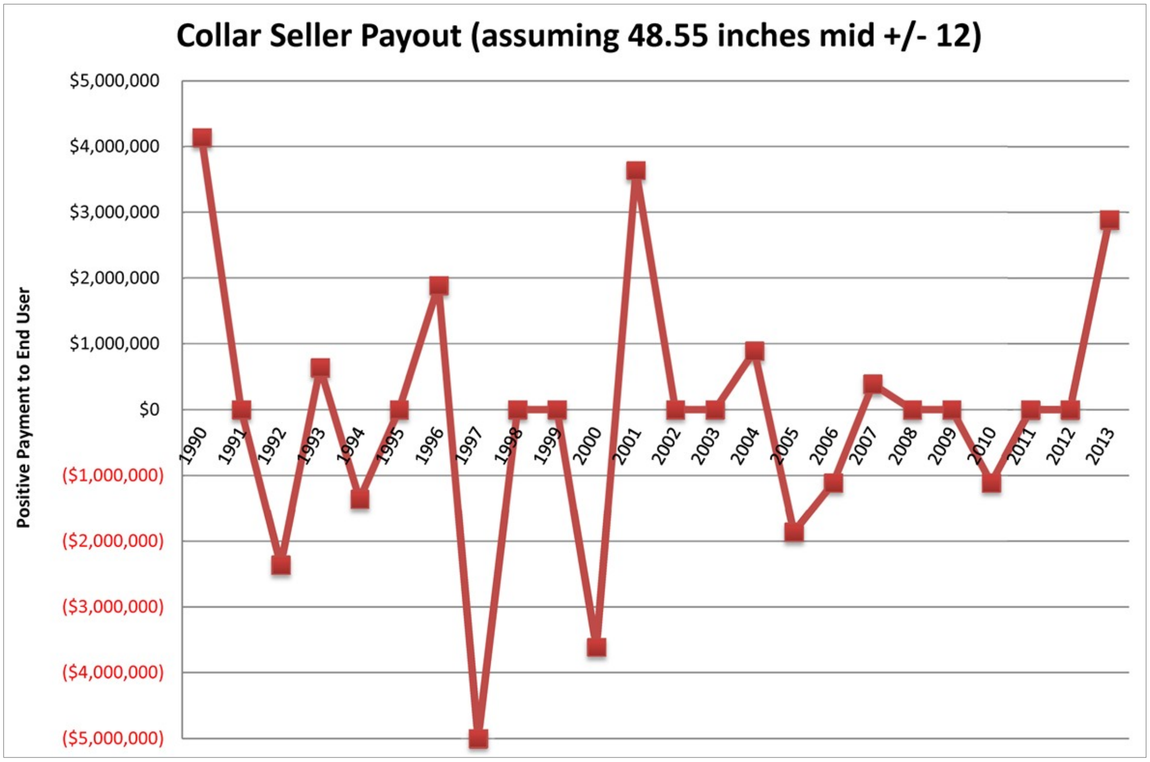


Instrument: Collar on Cumulative Rainfall (hedges End User against low rainfall)
Weather Index: Cumulative Rainfall at Location Z
Term: January-December 20XX

Seller: End User (will receive payment below the Put Option Strike and pay out above Call Option Strike)
Call Option Strike: B inches above Swap Strike when End User is Seller of swap
Put Option Strike: B inches below Swap Strike when End User is Seller of swap
Notional: $250k per inch of rainfall
Contractual Cap: Optional, but assumed to be $5MM
Premium Paid: None
Maximum Potential Gain to End User: $5 million
Maximum Potential Loss to End User: $5 million

COLLAR PRICING (END USER SELLING)
UPPER STRIKE = 12 ABOVE SWAP STRIKE
LOWER STRIKE = 12 BELOW SWAP STRIKE
NOTIONAL $ 250,000 per inch

YEAR	INCHES OF RAINFALL	SWAP STRIKE DETERMINATION AVERAGE RAINFALL	NET PAYOUT BEST EXPECTED COLLAR +/- 12 (AROUND 48.55)	NET PAYOUT WORST EXPECTED COLLAR +/12 (AROUND 47.08)
1990	20	49.04	$4,137,500	$3,770,000
1991	46		$0	$0
1992	70	1% of AVERAGE RAINFALL	($2,362,500)	($2,730,000)
1993	34	0.49	$637,500	$270,000
1994	66		($1,362,500)	($1,730,000)
1995	56		$0	$0
1996	29	4% of AVERAGE RAINFALL	$1,887,500	$1,520,000
1997	82	1.96	($5,000,000)	($5,000,000)
1998	59		$0	$0
1999	48		$0	$0
2000	75	BEST EXPECTED SWAP STRIKE (1%)	($3,612,500)	($3,980,000)
2001	22	48.55	$3,637,500	$3,270,000
2002	48		$0	$0
2003	58		$0	$0
2004	33	WORST EXPECTED SWAP STRIKE (4%)	$887,500	$520,000
2005	68	47.08	($1,862,500)	($2,230,000)
2006	65		($1,112,500)	($1,480,000)
2007	35		$387,500	$20,000
2008	40		$0	$0
2009	46		$0	$0
2010	65		($1,112,500)	($1,480,000)
2011	42		$0	$0
2012	45		$0	$0
2013	25		$2,887,500	$2,520,000
		AVERAGE PAYOUT (+ IS NET TO END USER)	($81,771)	($280,833)
		FREQUENCY OF (+) NET PAYOUT	7/24	7/24
		MAXIMUM GAIN TO END USER	$4,137,500	$3,770,000
		MAXIMUM LOSS TO END USER	$5,000,000	$5,000,000



As a general rule, swaps and collars are typically zero premium. However, it may turn out that a premium is requested or offered by the Seller or Buyer, depending on the magnitude of the expected profit that is expected from the historical analysis of buying and selling the various positions due to the choice of the Swap Strike or a Contractual Cap being placed on one of the legs of the structure.

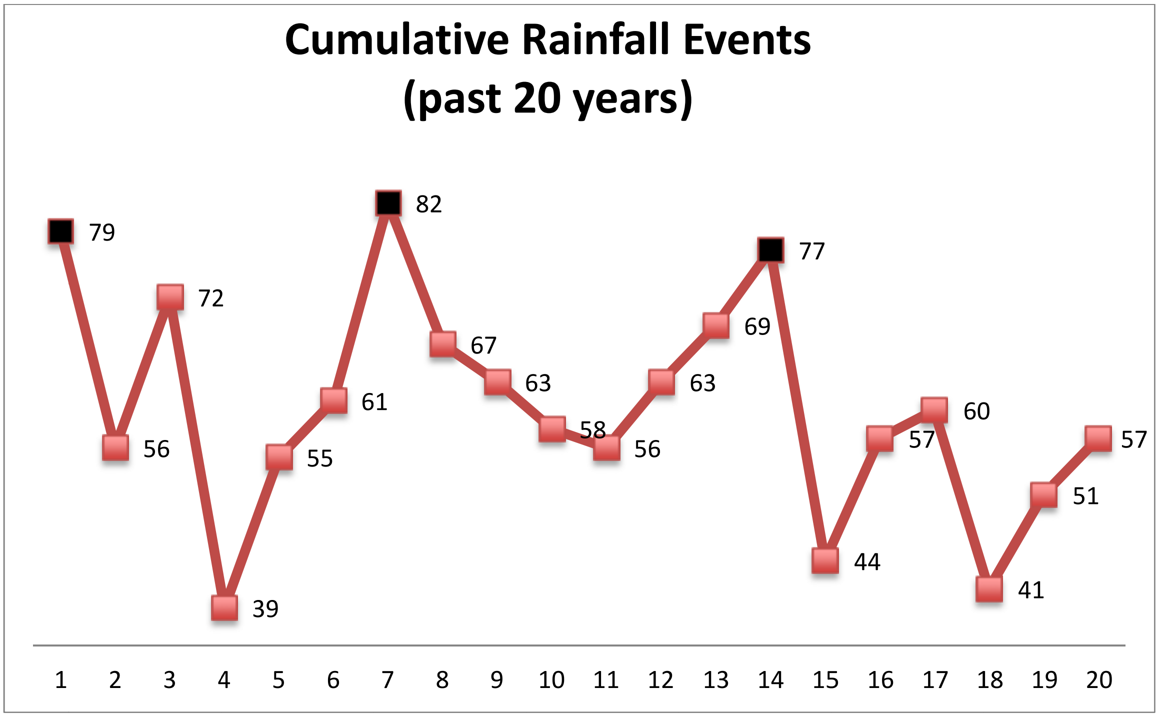
Case Studies for Water Suppliers

This section shall provide hypothetical examples of weather risk and mitigation techniques for water suppliers. These have been derived based on historically observed weather risks and potential adverse economic impacts likely to be felt. The solutions are created to show how such risks could be mitigated in the future.

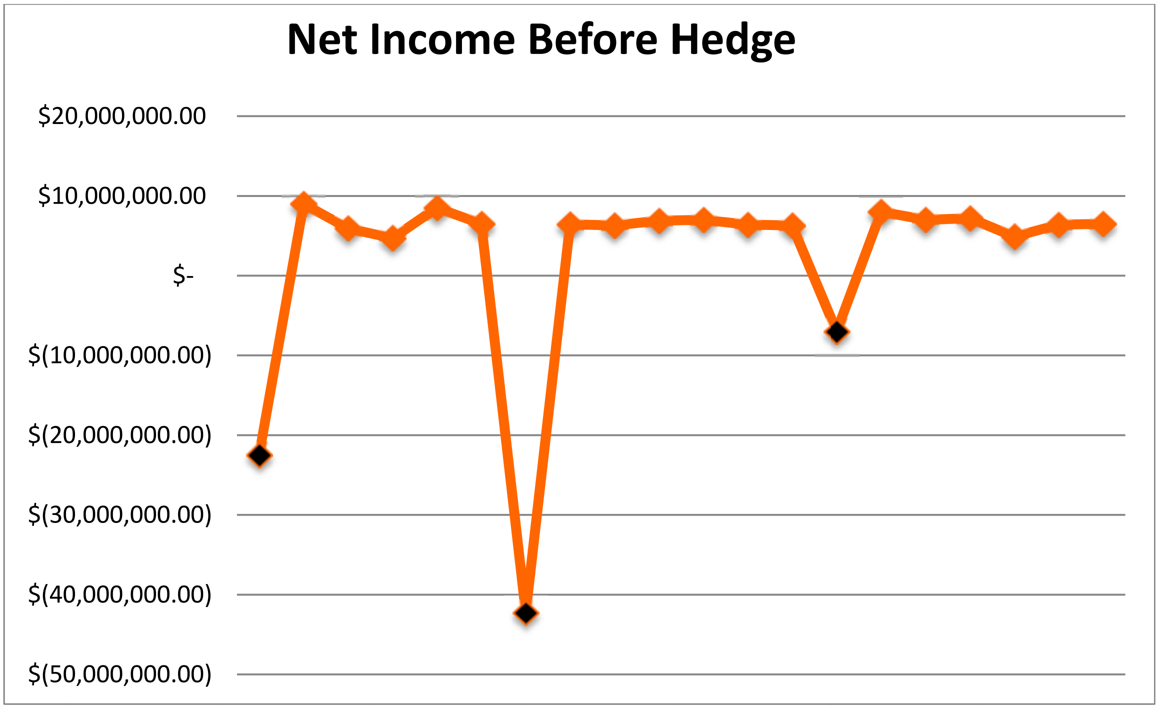
CASE STUDY 1:
SCENARIO:

- Water Supplier A sells 50% of its water during the peak season of June 16 – Sept 14
- Peak season sales are important for recovering operational costs of $150 million
- When higher than normal rainfall occurs, revenues are reduced and in some years the operational costs are not met
- An analysis of historical data shows that high Cumulative Rainfall Events correlate well with lost revenues
- Rainfall Events are defined as:

0 - 1” in one week = 3 events
1.01 - 2” in one week = 7 events
2(+)” in one week = 9 events



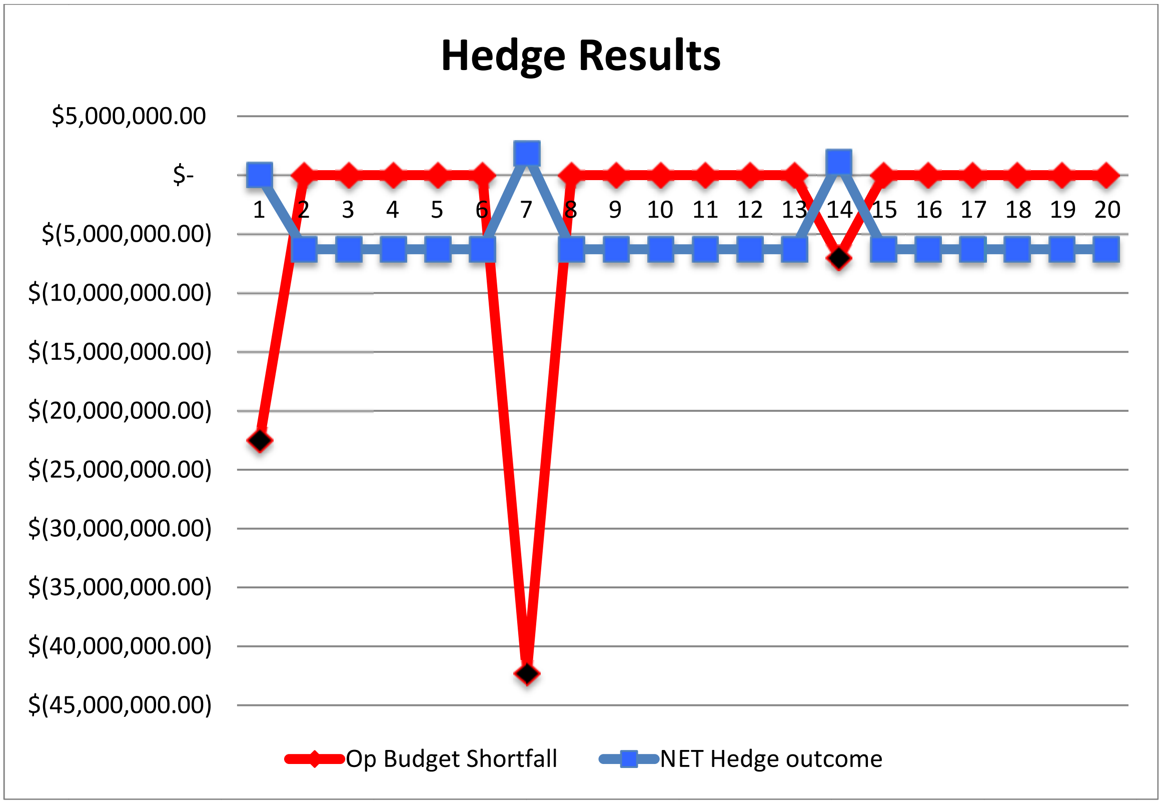
The blackened cumulative rainfall event observations on the chart above occurred and had significant negative impact to the water supplier as observed in the chart below of Net Income before any hedge. Losses were significant (in excess of $8 million) in years 1, 7, and 14.

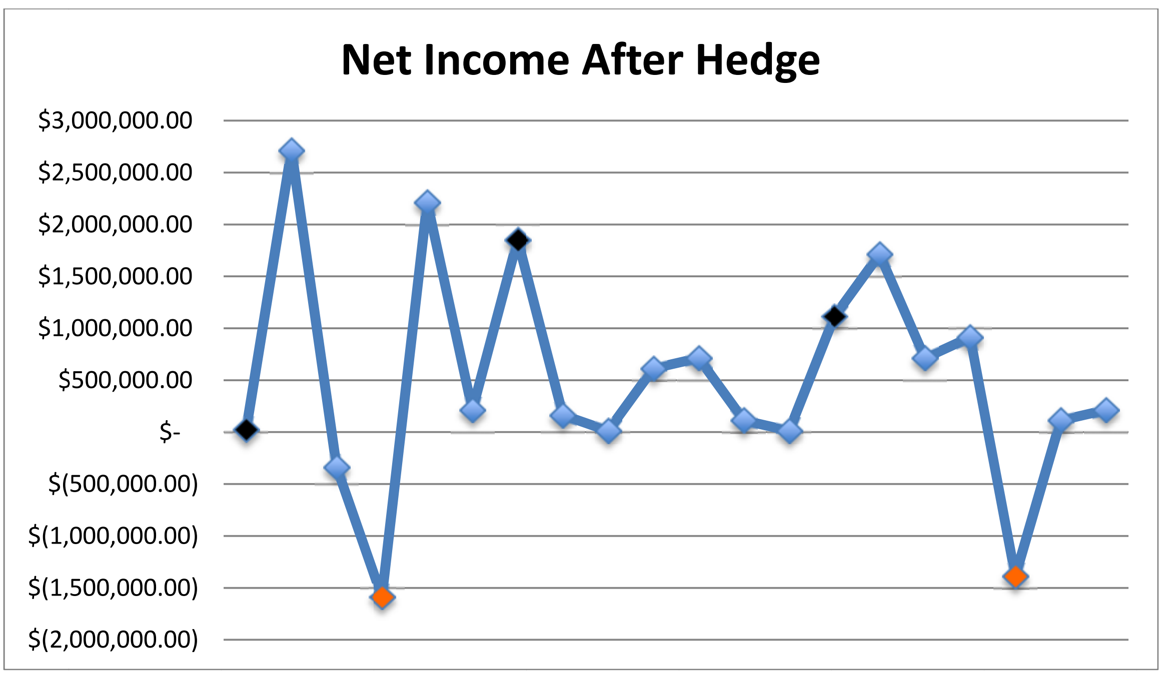


SOLUTION:

- Water Supplier A buys a Cumulative Rainfall Event CALL OPTION for $6.3 million annual premium which pays $7.2 million per Rainfall Event above a strike of 75 Events

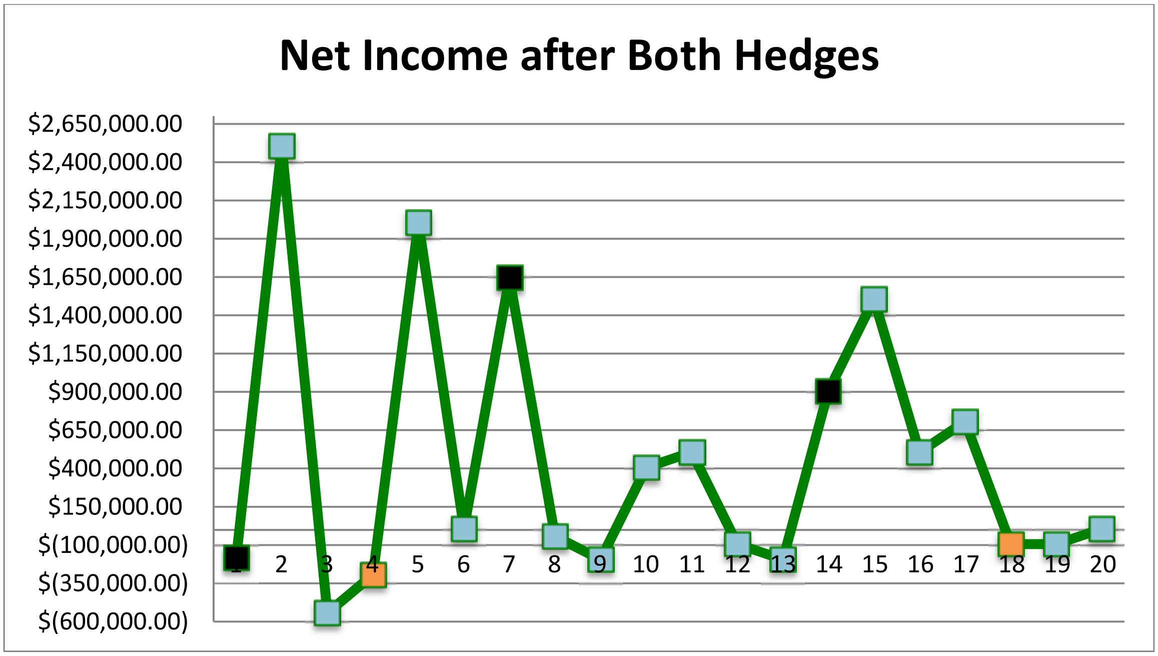
Note that the structured solution attacks the problem as depicted with the blackened data points in the time series (years 1, 7, and 14). The solution was derived through empirical analysis which yielded a high correlation with the defined weather index and the economic losses. The cost of the call option was defined by assuming it would be 12.5% of a standard deviation of the historical gross payment for such instrument added to the average gross payment collected.





As observed above, the call option structure on rainfall events muted the water supplier's high water risk as seen in the Net Income After Hedge graph. The call option had a cost that reduced profitability in all other years, but has left the municipality with an economic profile with much lower variability.

This profile could be further muted by additionally buying a relatively small put option on Cumulative Rainfall Events that target year 4 and 18. Hypothetically a structure could be purchased to cover $1.5 million in losses for approximately $210k (assumes 12.5% of standard deviation added to average gross payout). This would yield the final Net Income After Both Hedges profile. Whether a municipality's Board of Directors and risk managers take this extra step to mute the risk further is subjective. It is far less impactful than the call option, but has further reduced volatility by $1.5 million at a cost of $210k per year.



CASE STUDY 2:
SCENARIO:

- Water Supplier B experiences lost sales during drought restrictions which are enacted due to low precipitation and runoff
- Average Annual Demand = 22.075 million gal
- Water usage curtailed at 91.7% of normal lake levels per state regulation
- Lost water sales expected to be 1.721 million gal (15% peak demand)
- Cost of implementing drought restrictions = $500k
- Average price per gal sold = $4/gal
- Lost sales = $6.884 million
- Avoided Supply Costs = $3.065 million
- Lost revenue to hedge = $4.318 million

Large Western Lake Historical Data (assume drought restrictions state imposed at 1095)

SOLUTION:

- Water Supplier B buys DIGITAL PUT OPTION on lake level index that pays $4.318 million (either net of premium or gross depending on management's objectives) if the lake level is measured below 1095 on a given day within a calendar year
    - A DIGITAL OPTION pays out in a lump sum if the strike is exceeded (not gradually as previously explored)
- The approximate cost of a digital put option would be expected to be $590k
    - Historical Frequency of Loss: 6x since 1940
    - Average Gross Payout = $350k
    - Std Deviation of Gross Payout = $1.2 million
    - Digital options typically require a slightly higher risk premium by the market
    - 20% Std Deviation of Gross Payout = $240k

CASE STUDY 3:
SCENARIO:

- Water Supplier C suffers significant harm when it experiences two consecutive years of bad weather
- The risk is both to high rainfall which limits higher net revenue sales and low streamflow within the water supply watershed which increases costs of supply.
- The losses suffered in any one year are deemed by management to be acceptable
- However, a year of significant loss (defined as $25 million from weather events) followed by a second year of losses in excess of $5 million is deemed unacceptable by management, as rating agencies have warned the level of

financial leverage the municipality is carrying is high and they do not have faith that the water supplier can recoup such losses fast enough from the rate payer base in times of duress.

- Under the consecutive years of loss scenario, it is anticipated that several outstanding series of municipal bonds which carry extra costs (bank fees and higher interest rates) when the municipality is downgraded will lead to an incremental cost level of $25 million each year until the credit rating is restored. It is not expected this rating can be restored until its capital expenditure program is complete in 4 years.
- The water supplier expects to carry a relatively high level of leverage for 4 more years until a capital expenditure program is complete and new, guaranteed revenues from a large industrial complex will begin.

SOLUTION:

- The risk transfer required is a customized one involving multiple instruments and strikes.
- It is determined that the best solution will be a multi-year solution with up to 3 payments being allowed over the next 4 years (i.e. after year 2, 3, and 4).
- The Contractual Cap for each year shall be $40 million with an overall cumulative limit of $120 million.
- On a rolling basis, the derivative solution will conduct a First Year Test and look back on the previous year's weather results and determine if a $25 million loss occurred from the two defined weather events in combination (i.e. higher Cumulative Rainfall Events than X strike and lower than historical average annual streamflow) per defined payment terms.
- If a loss of $25 million or more is experienced, for the year after this loss event the same tests shall be applied but with a lower strike of Y for the call option on Cumulative Rainfall Events and Z for the average annual streamflow index. If the two options in combination payout in excess of $5MM, the calculated payout above this $5 million payment strike shall be paid up to the Contractual Cap for the year of $40 million.
- In the event that a payment is required in this successive year, it shall be paid at year end.
- The process of measurement for the next two year sequence commences through year 4.

HISTORICAL RESULTS OF CUSTOMIZED STRUCTURE AND ESTIMATED PRICING

Year	Year 1 Loss Amount	Year 2 Loss Amount (using different strikes)	Resulting Payment to Municipality C	Average Gross Payment
1990	$55,000,000		$0	$504,167
1991	$0	$0	$0	
1992	$0	$0	$0	Standard Deviation of Gross Payment
1993	$0	$0	$0	$2,469,902
1994	$22,000,000	$0	$0	
1995	$300,000	$0	$0	Expected Premium
1996	$40,000,000	$0	$0	$1,450,000 to $2,950,000
1997	$0	$0	$0	
1998	$0	$0	$0	
1999	$0	$0	$0	
2000	$0	$0	$0	
2001	$0	$0	$0	
2002	$0	$0	$0	
2003	$10,000,000	$0	$0	
2004	$20,000,000	$0	$0	
2005	$0	$0	$0	
2006	$0	$0	$0	
2007	$0	$0	$0	
2008	$0	$0	$0	
2009	$0	$0	$0	
2010	$26,000,000	$0	$0	
2011	$14,000,000	$17,100,000	$12,100,000	
2012	$0	$0	$0	
2013	$0	$0	$0	

Note that the premium level for this product is not calculated as simply as previously shown due to the fact that no historical observations of loss have occurred in years 2 and 3; yet there is a risk that it does occur. Proprietary statistical models will be used to come up with simulated loss experiences and risk premiums will be imposed based on the diversifying elements this contract presents to a risk takers existing trade book. The risk takers will also take into account the amount of capital this transaction consumes as most risk takers hold back some cash in expectation of paying out (either on a self-imposed basis or due to regulatory constraints). Some sellers of these kinds of products will impose a crude, minimum rate on line provision to determine an acceptable premium (% of the overall limit provided to the end user; in this case $120 million) to assure enough return is provided. 2.0 to 2.5% is a reasonable high end rate on line to assume for this kind of risk.

Comparing and Contrasting Weather Insurance and Derivatives

While this paper largely focuses on derivative offerings, it would be amiss if it did not offer a more detailed introduction to insurance products for weather.

Brief History

For the first few years right after the weather derivative market started, the insurance and reinsurance market struggled with how insurance and reinsurance products would co-exist in this new world of derivatives and specifically weather derivatives. The weather derivative market was initially deemed a threat to traditional insurance because the additional risk transfers (some with premiums paid) were viewed as insurance premiums lost to the industry. However, up to that point, weather risk was not explicitly underwritten in insurance or reinsurance contracts because the governing bodies of insurance and reinsurance struggled to accept an arbitrary figure attached to a weather contract as an acceptable and provable loss to the buyer of the contract. In addition, the use of zero premium collars and swaps was equally as perplexing to the industry at the time as insurance and reinsurance must involve a premium being paid. Finally, documentation of weather derivatives at the time was foreign to insurance companies that underwrote policies using strictly regulated insurance contracts that were not universally governed but instead governed state by state within the United States.

Reinsurance companies, due to their investing practices of the time, were set up to take on derivative risk and were the first to enter the pure weather market.

It should be noted that while the United States saw a proliferation of derivatives being used in the late 1990's and onward, several countries around the world (e.g. South Korea) would not allow derivative contracts in risk transfers because they were deemed to perpetuate gambling. Insurance contracts were the only risk transfer vehicle allowed in these countries. For instance in South Korea, weather insurance contracts were written to offset agricultural risks such as lost yields of fruit due to ill-timed freezing temperatures and, in at least one instance, to offset losses associated with a cell phone promotion marketing campaign that offered an individual a rebate on future bills if temperatures reached certain levels during defined windows of time. These insurance contracts made a weather event during a specific window of time an explicit trigger that must be breached before an insurance adjustor would assess any potential loss.[8]

For about 10 years, much work was done within the insurance and reinsurance industries to get the various regional regulators to allow pure weather insurance policies to exist. Most reinsurance and insurance companies found that these contracts most easily fit inside their Excess and Surplus (E&S) lines of business.

[8] Swiss Re and AXA Re.

Current Conditions

Pure weather insurance contract volumes still pale in contrast to weather derivatives. The structural flexibility of weather derivatives, the lack of requirement for a premium to be paid, the fact that the weather derivative contract pays out per a defined formula and within days of the last required weather value being reported, and the lower governance cost (insurance has a fee to the local regulator included whereas derivatives have no such fee) have continued to make derivatives the preferred instrument of most that seek a pure weather risk transfer around the world.

However, weather related risk transfers for catastrophic risk events such as flooding, hail, hurricanes, high winds, and drought where the weather event is an explicit or implicit trigger in an insurance policy to cover an asset being damaged such as a house, car, industrial plant, or commercial real estate continue to dwarf the weather derivative market in both notional risk transferred and sheer volume of contracts all across the world. Sometimes weather related risks are indirectly covered by business interruption insurance as well. The common complaint by many seeking business interruption insurance is the high level of deductibles defined in lost business days to achieve a favorably priced policy as the insurance companies seek to offer very low probability event risk mitigation. Many dams around the world utilized for hydroelectric power are known to carry these kinds of insurance policies. Crop failure risk (which is frequently directly related to bad weather events) is yet another form of implicit weather risk transfer for which the insurance market offers policies; often with direct subsidies from the government (in most countries). Weather derivatives are sold to the agriculture sector every year, but in relatively small volumes and notional risk transfers relative to these highly subsidized insurance policies. Many farmers have learned to utilize the best priced weather options and insurance policies (as defined by their coverage level) in concert with one another to get the most cost effective coverage.

Some pure weather insurance is executed but a premium must be paid, a maximum payment from the insurance company must be defined, and the policy's loss must be carefully defined in order to avoid the invalidation of a loss claim. A failure to perfect this language can result in a delayed, reduced, or possibly lost expected payment to a hedging party. Most insurance companies have developed policies which provide a broad definition of loss (as is available in their E&S lines) in order to make the payment of a weather insurance policy a virtual certainty if the weather event is triggered. When structured correctly, weather insurance can closely mimic a weather option's payout.

One additional, but very important driver that has some entities using insurance versus derivatives is the fact that their governance body only authorizes insurance purchases for risk mitigation. Many municipalities and public sector water suppliers are expected to fall into this category. It may be possible to seek and receive an exception from the appropriate governance committee, but all banks and other derivative participants will not transact with a government or municipal entity unless they are duly authorized.

SAMPLE TERMS FOR A WEATHER INSURANCE POLICY:

Type of Insurance Product: Varies in format by region of regulation, but usually constructed so that it fits into a format that allows the insurance company to successfully use its Excess and Surplus line of business for underwriting

Buyer: TBD, in most instances can be individual, municipalities, coops, or corporations

Seller: Insurance Co. X

Insurance Regulator: Should be from a specific state (if US) or country within which this kind of insurance policy can be underwritten

Rating of Insurer: Typically AM Best Rating is supplied which is an alternative rating agency to S&P, Moody's or Fitch but specifically for insurance companies. Usually a more traditional rating agency's rating is accessible if requested.

Term of Coverage: Start date and end date defined, but may be structured to match reinsurance cycles for renewals

Weather Trigger Event: TBD, but can be as bespoke as any derivative definition with location(s), weather reporting entity, weather index and strikes or thresholds of exceedence all being included in this term.

Deductible: TBD, but usually defined in $X or can also be defined in terms of quantity (e.g., gallons of water, lost business days, Mwh, bbls of fuel for running pumps, etc.) which then typically has a price dictated to each unit of measure per a definition in the contract

Premium to be Paid by Buyer: TBD (typically there is a 10% additional cost for brokers to be mandatorily involved), but always required. Sometimes offsetting positions (similar to a collar format in derivatives) can warrant partial consideration and therefore a reduction in cash premium paid if approved by the Insurance Regulator and is something that an Insurance Co. can track and accurately report in their financials.

Definition of Loss: TBD, but can be contingent on if a defined Weather Trigger Event occurs AND the Deductible is met; THEN a claim of loss is allowed. The amount of claimed loss can be defined by formula like a derivative (with the additional netting of the Deductible) or be left somewhat subjective to a claim adjustor that must look to the definition of what is covered under the policy. In all instances, a claim cannot exceed what an entity can actually display as an experienced loss. Any offsets to a formulaic based loss that an insurance company can claim should be carefully defined so that the insured party is not surprised or left seeking arbitration or litigation to achieve a full payment of claim. For example, sometimes losses that are perceived by the Buyer to be covered under an insurance contract are actually deflected to another form of policy by insurance companies in an effort to avoid paying out on a claim (e.g. defining flood vs. storm surge damage (i.e. loss) from Hurricane Katrina) when language is vague and hence a dispute arises that takes long periods of time to settle.

Excluded Events of Loss: Frequently, a policy cannot take effect before a certain date or for a risk which is perceived as likely at the time of the policies execution to avoid a claim coming from an already expected event that the Buyer anticipates (e.g., most new hurricane triggered policies are not enforceable for any tropical disturbances in the Atlantic Basin if they exist on the date the policy is executed or for a minimum of 3 weeks) or for any reason that occurs due to the Buyer influencing an act of destruction that might trigger a claim of a loss. Any form of exclusion can be included in an insurance policy and it is the Buyer's responsibility to understand any exclusions embedded in the language of the insurance policy. Usually the greater number of exclusions, the lower the Premium to be Paid by Buyer.

Maximum Potential Loss to Insurance Co. X: Will be explicitly stated as $A and is a mandatory term of any policy

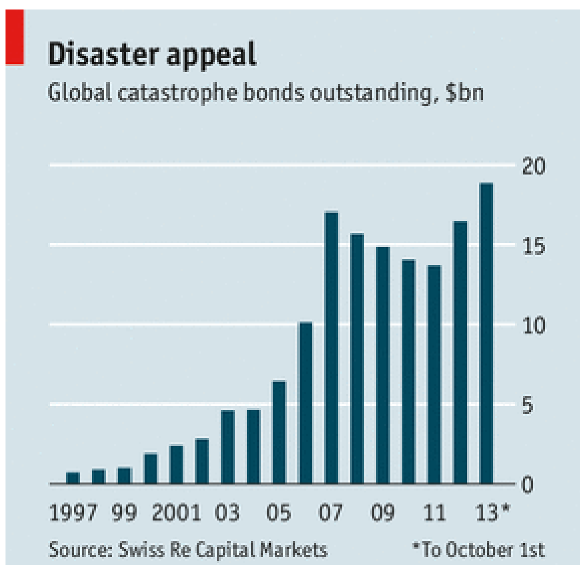
How to Make a Claim: Usually there are explicit steps that must be followed to file a loss claim to ensure an insurance claim adjustor is armed with sufficient information to determine loss and any other restricting elements agreed to per the policy executed.

Weather insurance policies can be structured to cover any of the weather scenarios depicted in the derivative examples presented earlier in this white paper; with the possible exception that most insurance companies are unlikely to allow the underwriting of a probability of loss threshold of greater than X% (e.g., typically 10 - 25% per the underwriting standards of each insurance company and possibly per the Insurance Regulator). Therefore, the buying of an insurance policy with coverage that kicks in at the strike of a swap (approximately 50% probability of exceedence) or even more in favor ("in the money") may not be allowed. Even if the Weather Trigger Event can be set at a very high probability it is quite likely a substantial Deductible may have to be established in order to ultimately achieve a lower probability of exceedence which would closely match a less probable Strike in a derivative contract.

Bond Structures to Consider

Through the years, various bond structures involving variable interest rates and principal repayment have been explored with a wide variety of success. At least two bonds, as previously mentioned, have been issued that have their cash flows change based on a weather index and outcome (i.e. either due to temperatures or wind speed exceeding a defined level). Accounting rules and the general appetite for these bonds (both on the risk-shedding and absorption sides of the equation) are changing constantly, so the applicability of embedding weather risk (like precipitation, streamflows, or lake levels) into a bond may or may not ultimately appeal to a water supplier manager.

Currently, investors are clamoring for more fixed income instruments that are frequently more exotic and carry insurance-like risks. These investors are seeking low beta (i.e. low correlation with the broader financial markets) and relatively high alpha (i.e. expected returns over time are high relative to the risk undertaken). If one observes the growing Insurance Linked Securities sector (see Economist chart below which was supplied by Swiss Re), one will see that since the late 1990's the size of the Catastrophic Risk ("cat risk") bond market has grown steadily. Cat risk is a segment of this growing industry.



Source: Economist, October 5, 2013

Cat risk bonds take many forms, but many are parametric structures (i.e. bonds with payouts that are defined by an event driven formula based on an observable index) versus those that have their payments change based on the estimated loss for the industry that is supplied by a third party estimator or those related to a specific company's losses related to business interruption or to property loss. Traditional weather risk is viewed by investors to be a parametric risk. Most pure weather risk that has been transferred via derivatives has involved a risk transfer of relatively high frequency, but this is not necessarily a requirement if water suppliers elect to transfer a severely damaging but low frequency risk to the market. To date, most parametric cat risk structures have targeted natural catastrophe events (i.e. hurricanes and earthquakes) of low probability. Very few of these investments have created losses for investors, and therefore an inordinate amount of investor money is seeking this asset class. Hence, it would be very appropriate and timely for a municipal water supplier or set of regional suppliers to explore the issuance of a water related parametric bond that has a probability of loss of less than 2-5% (or a one in 20-50 year event). To justify the associated costs of a bond issuance, it likely requires a risk transfer of $50-250 million over a five plus year period.

It is the perfect time to explore the value proposition of issuing a municipal bond or a municipal sponsored bond that offers a water supplier or a set of water suppliers access to a new and unique set of investors quite willing to share one of their primary and uncontrollable risks. One avenue to pursue would be for the water supplier to issue a bond that has its overall interest expense and possibly its principal repayment reduced if an adverse weather event occurs. This bond could allow both funding for replacing other higher cost bonds or to support capital expenditures.

Another means to explore a weather event related bond could also be through having a structured note as an investment vehicle versus a funding vehicle. In this structure, the water supplier would take excess funds that it is capturing, and which might already exist in a self-insurance pool, and put them into a variable rate bond investment that yields a higher return when water does not appear as expected. The main benefit here is that the investment vehicle would put excess funds into a more permanent vehicle remote from politicians' periodic raids to fund other general fund activities, as the breakage cost of the contracts for the purpose of reallocating the funds to another section of government could be made prohibitive. In addition, the investment yield would be a better fit for the water supplier versus getting paid a traditional market based yield. If this investment vehicle is constructed with weather options, very extreme weather events could provide well above market returns at just the right time to offset lower net income.

There is limited precedent for bonds being a primary vehicle through which weather risk is transferred, but there are potential applications that water suppliers should explore as markets are constantly evolving and demand is currently high for alternative investments.

Conclusions

Weather risk is significant for water suppliers selling water to their municipal and regional consumers. The risk takes many forms, and a wide range of imperfect solutions are currently available to this industry.

It is important that the financial impact of weather on a water supplier's annual revenues be carefully determined with the guidance of senior management and often with the required assistance of management from the planning and financial departments. Further outside assistance is also readily available from outside consultants who retain tremendous expertise. In reviewing the range of financial expectations under various weather events and determining the "pain point" for a water supplier, a structure can then be developed to mitigate the potential experience of more pain than can be tolerated. This structure could then be priced in the market place and the water supplier would have the right to buy or not buy the structure. The actual format of the hedge could take the form of a derivative, insurance contract, or bond depending on the current market conditions and the authorizations available to the team executing the hedge. Any structuring work performed may further lead to a range of other structures being identified that also can be priced to allow a water supplier to flatten its risk profile.

In the end, a mixture of weather hedges and other risk management techniques will likely prove to be the best combination to improve the financial health and stability of water suppliers in the United States.

Appendix 1 – Glossary of Terms

Financial Instruments available in the derivative world are options, collars, and swaps. A myriad of combinations of each are possible to tailor fit a set of derivatives to a client's risk profile.

In summary, options are derivative contracts that require a premium to be paid. Options are commonly mislabeled as insurance contracts due to their risk profile being somewhat similar. When options are bought or sold, a premium passes from the Buyer to the Seller. The amount of loss the Buyer can encounter in such a risk transfer is only the premium paid. The Seller, however, can be exposed to an unlimited loss that translates into an unlimited gain to the Buyer. The Buyer of an option is buying the right to exercise (automatic exercise is common in weather) at a later date if a certain outcome occurs (e.g., a rainfall strike level is exceeded). If the contract is one that pays out when a strike is exceeded to the high side (higher than a strike level), it is a Call Option. In contrast, if a payout occurs when a strike level is exceeded to the low side (lower than the strike level), it is called a Put Option. Swaps and collars are pairings of Put and Call Options where the Buyer of a Put or Call option (provided by a Seller) accepts downside risk by selling to that Seller of the original contract the other type of option that pays if the defined risk realizes in excess of the strike the buyer is willing to sell. If the paired Call and Put options share the same strike level and have the same Notional Amount the resulting pair of Put and Call options can be referred to as a Swap. If the paired Call and Put options have different strikes then the structure is called a Collar (or fence). Collars and Swaps can be symmetric in nature; which means no additional premium is required for two parties to enter into such a trade because the instruments paired are of similar market value. However, if the Notional Amounts are set differently for each option or the strikes are set in a manner where one counterparty sees that they are receiving what is perceived to be a less valuable option contract in return, that party may request an additional premium. If this occurs the structure is deemed to be an Asymmetric Collar or Swap.

The *Weather Index* chosen is one that the Buyer and Seller collectively agree to settle a contract on. It must be pre-defined to firmly set an important piece of the value function at the end of the contract. Weather Indexes can vary widely and cover a wide range of weather measurements such as temperature, precipitation, streamflow speed, lake levels, solar irradiation, and wind speed. They can be hourly, single day, weekly, monthly, or customized date range (seasonal) values. They can be the high, low or average values. For example, a simple Weather Index may be the Cumulative Precipitation or the Average Daily Rainfall during a defined period.

Realized Weather Index is the value of the weather indexed that is observed during a contract's Term.

Term in a weather derivative contract defines the start and end date for weather measurements to occur. Again, the range can be customized. On dual commodity products such as water contingent diesel, the measurement of each underlying's value do not need to overlap in time but again must be defined in advance.

Weather Measurement Location is defined to be one or more weather stations where a fair reading can be taken during a contract's Term. The location chosen should have a historical record for the Weather Index chosen that provides 10 plus years of history with few holes in the historical data set, to avoid a high risk premium being imposed. Frequently, government monitored and recorded locations (such as NOAA's) are used in contracts. Third party stations can be used if validated by one of a host of meteorological firms that can sufficiently monitor alternative stations and therefore can police against fraud.

Weather Data Provider is the entity that supplies the Settlement Data to the Settlement Agent. Commonly it comes straight from the entity that monitors the Weather Measurement Location, however, collection and distribution entities such as Speedwell and Earthsat are frequently used. Both of these entities are used by the CME to report their settlement values.

Buyer and Seller must be defined in advance so that each party knows its obligations in a derivative contract.

Strike is a threshold level of the defined Weather Index that if exceeded prompts a payment. In option contracts if the Strike is not exceeded no payment will flow from the Seller to the Buyer. If the strike value is achieved exactly in a swap contract no payment ensues, however, any other value will result in a payment from one party to another.

Notional Amount is the amount that a Buyer wants to be paid in the event the strike of the option owned is exceeded. This is typically seen in graphical form to be the slope of the line that matches revenue or net revenue plotted against the Weather Index value.

Contractual Limits of Buyer/Seller to other party is an optional provision in a weather contract. If desired, it limits the loss one party can incur to the other. Contractual limits when imposed on a structure lower that instrument's value.

Settlement Value is the calculated amount that comes from a pre-defined function and that involves the variables defined up front in the contract. Typically it is the max (0, (Notional Amount times [the Realized Weather Index LESS the Strike])) for a Call Option. For a Put Option, it is typically the max (0, (Notional Amount times [the Strike LESS the Realized Weather Index])). For a swap it is typically the (Notional Amount times [the Realized Weather Index LESS the Strike]). This payment is typically sent by wire transfer.

Premium is a cash payment from the Buyer to the Seller of an option or from one party to another in an asymmetric collar or swap. It is usually paid upfront at the time of execution of a contract, but it can be deferred and financed inside the structure provided to match an entity's cash flow requirements.

Collateral Obligations provided by Buyer/Seller is the required security one party must offer to the other to provide that entity with comfort that at the end of the contract a payment will be made if actually required. These are negotiated amounts, if required, that are typically derived by analyzing a counterparty's credit strength and the risk profile of a transaction. Collateral can be held in a party's bank account for collateral, or in a third party escrow account. Collateral typically comes in the form of cash, a Letter of Credit from an investment grade third party such as a bank, or the pledging of a hard asset. Any shortfall in payment due to a default can be pursued in court, but in the interim the collateral often can be claimed and held indefinitely to partially or wholly cover the obligation that was not met. If the collateral proves to be more than required, any excess is typically returned at the end of the trade's outcome. Sometimes collateral amounts to be returned are netted against required Settlement Value payments for ease of settling, but this is not typical.

Exercise Method is either automatic or manual. Automatic exercise means the party owed in a contract does not need to take action to get paid. Manual exercise requires the party expecting payment to contact the other party and exercise their right to claim its contractual rights under the contract (including its Settlement Value). For weather the market norm is for automatic exercise which means that the Buyer does not need to communicate their intent to get paid under the contract. However, at the point of a trade's execution this should always be clarified.

Settlement Agent is the entity that is required to report the Settlement Value to the other party and typically sends an invoice for payment to the other party's back office team for processing.

Calculation Agent is the entity that makes the calculation of the Settlement Value per the contractual terms. Frequently, this is the Seller listed in the contract.

Premium Payment Date is the contractual date on which the party owing a Premium to the other is required to send such amount (typically by wire transfer).

Settlement Payment Date is the contractual date on which the party owing a Settlement Value to the other must make such payment (typically by wire transfer).

Eligible Contract Participant is defined by regulators to assure that an entity entering into a derivative contract is sophisticated enough to do so. It typically means that an individual, corporate entity, partnership, or other defined entity entering into such a transaction has $1 million in net worth or $10 million in assets. These thresholds are subject to change and with Dodd Frank legislation being imposed, such limits could easily change. Please check one's own eligibility before pursuing a derivative contract of any sort in order to avoid wasted time. It should also be noted, that municipalities have their own unique rules and some are not eligible to seek a risk transfer via a derivative contract. A Board Directive is typically required by derivative dealers in the weather market to assure they are transacting with a municipality that is an Eligible Contract Participant.

Dispute Resolution Methodology is a pre-defined contractual method for the Buyer and Seller to resolve a conflict. If something can be foreseen, then a formulaic path can be offered in the contract. However, frequently this term is used for unexpected problems. Arbitration is the most commonly chosen form of dispute resolution.

Rounding Methodology is typically a small detail, but it defines how the parties of the contract intend to handle the rounding of any amounts observed or calculated on a pre-defined basis.

Fallback Methodology in a weather contract is a pre-defined method for the Buyer and Seller to come up with missing weather data values that might occur for a wide range of reasons. One reason may be the station ceases to exist due to a catastrophe such as an earthquake or lightning strike. Missing weather data is not a common problem, but is something that must be addressed in bespoke structures and contracts. This provision must also be considered for other commodities in the event a price marker ceases to be reported.

ISDA Documentation is a set of legal rules and norms that are established by market participants to facilitate the execution of derivative contracts of all sorts including weather. Such documentation is common around the world. Weather derivative contracts have their own subsection in the ISDA guideline booklet to address common definitions, etc.

Risk Premium is the mark up over perceived fair value that a dealer will embed in a structure in order to feel they will on average profit from the transaction. It can be observed in the cash premium requested or a modification of the structure (e.g. moving the strike in a swap in the dealer's favor).

Secondary Settlements are not required in most contracts, but are not uncommon if a contract specifies the use of a less reliable weather data source. This language typically states that X days after a contract settles the first time, the Calculation Agent is obliged to recalculate the Settlement Value to see if the weather data has been amended by the reporting entity. Note, NOAA typically performs a quality check on the data it produces and is faster in doing so for "first order" stations vs. "second order" stations. "First order" stations are deemed to be of high importance for strategic, environmental sensitivity, and homeland security reasons. If a change does occur, a second Settlement Value will be calculated and any net difference form the first Settlement Value must be paid.

Author's Biography

John Polasek is the President of AIWEX, Inc. and Manager of Drop Tyne Investments, LLC. AIWEX, Inc. is an entity that provides consulting services on oil logistics, weather derivatives, and cross commodity trading structures. Drop Tyne Investments, LLC is an investment company targeting oil and gas production in the North America.

John has accumulated over 17 years of experience with commodities, finance, and insurance products while working at a broad range of bulge bracket investment banks (Deutsche Bank, JP Morgan, Bear Stearns, and Merrill Lynch) and one of the leading private commodity asset and trading organizations in the world (Koch Industries). John has been a leader within these organizations, serving in Director to Managing Director capacities, and been largely responsible for originating structured risk management solutions for a wide range of industries that utilize commodities in their business process. He has consistently led these institutions in structuring and developing new risk management solutions and hedging techniques. Marquis transactions that John have led or been extensively involved in include the development of oil by rail infrastructure projects within the US and Canada; credit intermediation structures for refineries and midstream asset companies which have significantly improved working capital capacity and lowered financing costs; various financing structures for the exploration and production companies; exotic commodity risk structures for institutional investors including power variance and correlation swaps; a broad mix of structures that have significantly eliminated the risk faced by the renewable industry and promoted further investment in the industry sector; and several large term risk mitigation structures for the agriculture industry. John has also had a very unique career experience and is an established leader in the weather risk management arena. He joined the industry one year into its existence (i.e. in 1999) and has served as the President of the Board of Directors for the Weather Risk Management Association (WRMA). The marquis weather derivative transaction he structured and executed while at JP Morgan was a risk mitigation contract with a Chilean hydroelectric company that suffered losses when drought conditions led to a need for increased energy purchases from third parties to meet contractual sale obligations to end users. It is the first and largest cross commodity transaction ever executed in the Latin American market place with a risk transfer of several hundred million USD. He also provided substantial structuring expertise to the regulated electric utility in Uruguay that executed its transaction with the World Bank in 2013.

John received his MBA in Finance and Marketing from the University of Texas at Austin in 1996 and his BA in Economics, Political Science, and Managerial Studies from Rice University in 1991. Prior to joining the traditional workforce, he played professional baseball from 1991 to 1994 with the Baltimore Orioles and Montreal Expos when an injury ended his pitching career.

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