BEFORE THE STATE OF WASHINGTON

ENERGY FACILITY SITE EVALUATION COUNCIL

In the Matter of Application No. 2006-01: ENERGY NORTHWEST; PACIFIC MOUNTAIN ENERGY CENTER	**EXHIBIT __** (TLM-T)

APPLICANT'S PREFILED TESTIMONY

WITNESS: TRAVIS LYNN McLING

Introduction

Q. Please state your name, current employment position and business address.

A. My name is Travis Lynn McLing. I am the chief geologist for the Big Sky Carbon Sequestration Partnership ("Big Sky").

Q. Please describe your educational and professional background.

A. I have been working in the field of Carbon Management and Sequestration since the inception of the US program in 2004. Prior to that time I was involved in mid-latitude

KIRKPATRICK & LOCKHART
PRESTON GATES ELLIS LLP
925 FOURTH AVENUE
SUITE 2900
SEATTLE, WASHINGTON 98104-1158
TELEPHONE: (206) 623-7580
FACSIMILE: (206) 623-7022

glacier research. The purpose of this work was utilizing data collected from mid-latitude glaciers to reconstruct the earth's climate over the past 1,000 years. A copy of my resume is attached as Exhibit ___ (TLM-1).

Scope and Summary

Q. What is the scope of your testimony in this proceeding?

A. My testimony will explain the various processes involved in geologic sequestration, will describe the state of the art of geologic sequestration science, and will discuss possible geologic sequestrations methods for PMEC.

The Process of Geologic Sequestration

Q. Please describe the process of geologic sequestration.

A. There are essentially three types or phases of geologic sequestration, each with its own process. These are hydrodynamic trapping; solubility trapping; and mineral trapping.

Q. How does hydrodynamic trapping work?

A. Hydrodynamic trapping the first of three active processes involved in geologic sequestration. The process involves the pressure trapping of carbon dioxide deep underground. The pressure for this type of trapping is provided by the overlying water column (2.31 psi/ft) which allows the carbon dioxide to be stored as a super critical liquid with a density of approximately 0.6 g/cc (which varies with depth). Because the hydrodynamic trapping stores carbon dioxide as a liquid less dense than water, it is capable of moving upward via density driven flow. For this reason, it is important that during early times of geologic carbon sequestration that the targeted form has an effective geologic seal. The seal will act as a barrier preventing the buoyant carbon dioxide from moving out of the target formation.

KIRKPATRICK & LOCKHART
PRESTON GATES ELLIS LLP
925 FOURTH AVENUE
SUITE 2900
SEATTLE, WASHINGTON 98104-1158
TELEPHONE: (206) 623-7580
FACSIMILE: (206) 623-7022

Hydrodynamic trapping is considered a short-term trapping method because over time the carbon dioxide dissolves into the surrounding formation fluids. Hydrodynamic trapping is considered rapid and reversible, that is if the pressure is removed then the carbon dioxide would be free to evolve out of the liquid phase. It is important to remember that in geologic environments this loss of pressure is exceedingly unlikely as the target formations have held saline fluids for tens of thousands to millions of years. Additionally, if carbon dioxide did leak from the formation it would likely be at extremely low levels and therefore it would likely be redissolved into overlying aquifers. In this manner overlying geologic formations provide additional safety buffers for migrating carbon dioxide.

Q. How does solubility trapping work?

A. Solubility trapping is the second step in the geologic sequestration process. In this form of trapping, carbon dioxide transitions from the super critical phase into a dissolved phase. Carbon dioxide has a high solubility in water and will readily dissolve into the formation waters. The dissolution of free phase carbon dioxide (super critical) into the formation fluids creates a weak acid called carbonic acid by the following reaction: $CO_2 + H_2O \rightarrow H_2CO_3$. The neutralization of carbonic acid in the formation is via the weathering or dissolution of formation rocks and the subsequent formation of secondary minerals such as carbonates (see mineral trapping). Dissolution of atmospheric carbon dioxide to form carbonic acid is the primary weathering mechanism in nature, and therefore does not require any manipulation of the subsurface geochemistry for solubility trapping to occur. Solubility trapping of the formation of carbon dioxide is the intermediate in geologic carbon sequestration and will proceed until the free phase carbon dioxide is consumed. The rate that this reaction will take is dependant on the formation brine chemistry and the interfacial surface area (the surface area of the CO_2 formation contact). In general the larger the surface area the more rapidly the reaction will proceed. Additionally, solubility trapping is considered to be nearly

KIRKPATRICK & LOCKHART
PRESTON GATES ELLIS LLP
925 FOURTH AVENUE
SUITE 2900
SEATTLE, WASHINGTON 98104-1158
TELEPHONE: (206) 623-7580
FACSIMILE: (206) 623-7022

irreversible as the chemical driving force is from higher concentration (free phase CO_2 bubble) to lower concentration (dissolved CO_2). It would therefore be very difficult for carbon dioxide to re-precipitate as a free phase.

Q. How does mineral trapping work?

A. Mineralization is the final step in permanent carbon sequestration. The previously discussed process (hydrodynamic and solubility trapping) are the first two steps in this process. It is important to note mineralization of carbon dioxide is a common process active in the subsurface and many target formation are already mineralizing carbon dioxide. In this step carbon dioxide that has transitioned from the free phase into the soluble phase by the formation of carbonic acid is converted to a secondary mineral. The reaction of carbonic acid with formation minerals results in the release of base cations (i.e. Ca, Mg, Fe, Mn, etc) and the formation of bicarbonate (HCO_3) similar to the following simplified reaction.

$$\text{Mineral} + H_2CO_3 \rightarrow (\text{Ca Mn Mg Fe}) + HCO_3$$

The base cations when combined with the free HCO_3 form a variety of carbonate minerals similar to limestone and clays (equation 2).

$$(\text{Ca Mn Mg Fe}) + HCO_3 \rightarrow (\text{Mn-Fe-Mg-}CaCO_3) + \text{Clay}$$

The secondary mineral that forms (see figure 1 at the end of my testimony) can be expected to persist indefinitely, effectively removing the carbon dioxide from the global carbon budget. The rate at which mineralization takes place is highly dependant on the type of rock involved in the reaction. A rock that has a large amount of base cations such as basalt is expected react very quickly, perhaps in as little as a few hundred years (see figure 2 at the end of my testimony). On the other hand a rock type that is composed of pure quartz may take thousands of years to react. This makes it exceedingly important to evaluate the formation and the time frames needed for the reaction prior to sequestration operations.

KIRKPATRICK & LOCKHART
PRESTON GATES ELLIS LLP
925 FOURTH AVENUE
SUITE 2900
SEATTLE, WASHINGTON 98104-1158
TELEPHONE: (206) 623-7580
FACSIMILE: (206) 623-7022

It is very important to note that the data for which these reaction time assumptions are made are based on bench or laboratory scale data. There are currently not experiments at the field scale that confirm these assumptions. However, in the coming year a number of large field experiments will be undertaken to evaluate the potential for geologic sequestration at near facility scale.

The State of the Art of Geologic Sequestration Science

Q. Please describe the state of the art of geologic sequestration.

A. The learning curve for geologic carbon sequestration is still very steep. Much information has been gathered and much more needs to be collected before geologic sequestration is proven to be a large-scale solution to our climate problem. The current push in the US is toward large scale pilot demonstrations (greater than 1 million tons /year) to provide a proof of concept for this technology. Although geologic sequestration is viewed in favorable light by the scientific community we are still decades away from seeing large-scale implementation. The sheer volume of carbon dioxide that must be injected into the earth to make a dent in the climate problem is staggering. If enacted geologic sequestration will represent the single largest perturbation to the earth subsurface ever undertaken. Aside from the environmental risks posed by geologic sequestration there is a sizable financial risk involved. I believe that currently, the technology does not exist to monitor the sequestered carbon dioxide to meet tax or financial liability standards. There needs to be a leap in the scientific community's ability to economically monitor and verify stored carbon dioxide. In short in my opinion much more needs to be known from a technical standpoint before we can count on the ability to sequester millions of tons of carbon.

KIRKPATRICK & LOCKHART
PRESTON GATES ELLIS LLP
925 FOURTH AVENUE
SUITE 2900
SEATTLE, WASHINGTON 98104-1158
TELEPHONE: (206) 623-7580
FACSIMILE: (206) 623-7022

Q. How do you expect that the additional scientific information will be developed, and on what time frame do you expect it will be completed so as to permit commercial-scale sequestration in the State of Washington?

A. Based on the current state of the science I expect that large-scale implementation of geologic sequestration at more than a few test sites will not occur before 2020. I base this conclusion on several considerations. The first is there are still many technical issues that need to be solved for geologic sequestration to be widely accepted, many of these issue will not be solved until large (millions of tons) field test are completed. Currently these tests are planned but will not be completed and evaluated until at least 2012. Second, there is not currently a US carbon tax or cap and trade program in place. Until such a time as the federal government moves on this topic, industry is unlikely to move to adopt expensive new carbon capture technology. Third, there is not currently a mechanism in place to permit a facility scale sequestration operation. Associated with this is the lack of legal precedent associated with ownership of the deep pore space needed for geologic storage. Law will need to be established and tested before large-scale implementation. Fourth, although the public is largely supportive of carbon capture and storage ("CCS"), experience has shown that once a facility is announced the "not in my backyard" mindset takes effect. Last, the most significant roadblock to implementation of CCS currently is the immense cost associated with capture, compression and transportation of carbon dioxide. Currently adoption of CCS with the existing coal fired fleet is prohibitively expensive.

Geologic Sequestration for PMEC

Q. Can you say at this point if geologic sequestration in a nearby formation would be an option for PMEC?

KIRKPATRICK & LOCKHART
PRESTON GATES ELLIS LLP
925 FOURTH AVENUE
SUITE 2900
SEATTLE, WASHINGTON 98104-1158
TELEPHONE: (206) 623-7580
FACSIMILE: (206) 623-7022

A. At this point it is still too early to say. The geologic terrain west of the Cascades is crossed with faults and has complicated structure, but our baseline geologic information suggests that sequestration in nearby saline aquifers may be possible.

Q. What needs to be done in order to determine what if any geologic sequestration would be appropriate for PMEC?

A. Energy Northwest would need to implement a three-step process. The first step would be a review of all available literature to see what is known about geologic formations that exist in the vicinity, to assess likely targets and the risks associated with these targets, and to identify key information gaps associated with these targets. Based on the results of that work, a testing plan would be developed. This second step would involve physical testing at promising locations in order to fill the information gaps. This physical testing should include geophysics, drilling, hydraulic testing and some sort of carbon dioxide injection test. Because the second step involves physical testing, it is expensive and time consuming. Finally, as a third step, Energy Northwest would select a final site and conduct economic and engineering studies to determine how to configure a sequestration facility at the location. Finally, it would seek to obtain all necessary permits, land rights, mineral rights, etc.

Q. Are you familiar with the evaluation of potential sequestration opportunities that Energy Northwest has engaged URS to perform?

A. Yes, I have reviewed that scope of work. They plan to perform a high-level survey of formations within 50 miles of the PEMC site. This survey will include a review of all available geologic literature, maps, geophysics, and deep well data. This information will be summarized and likely sequestration targets identified.

Q. Are you comfortable with the approach they are taking?

KIRKPATRICK & LOCKHART
PRESTON GATES ELLIS LLP
925 FOURTH AVENUE
SUITE 2900
SEATTLE, WASHINGTON 98104-1158
TELEPHONE: (206) 623-7580
FACSIMILE: (206) 623-7022

A. Yes, this is the first part of completing step one of the three step program. Because the test portion of this plan is so very expensive, I would recommend that step 1b include an evaluation of the formations identified using computer simulations to test injectivity, volume and leakage scenarios. If these simulations support sequestration then I would recommend that PMEC move toward the more expensive and complex drilling and subsurface testing. I recommend that Energy Northwest avoid rote execution of their plan in order to stay abreast of changing technology and policy.

Q. Once work on step 1 has been completed, what should Energy Northwest do in order to continue an appropriate evaluation of the potential opportunities for sequestration?

A. After the completion of both parts of step one, Energy Northwest should proceed with subsurface evaluation. The first part of this step would be the completion of a subsurface seismic profile. Evaluation of this profile should then be followed by a drilling operation and accompanying down hole testing. For this portion of the testing Energy Northwest should seek a collaborative effort with one of the entities that have participated in the equivalent of steps 2 in the Regional Carbon Sequestration Program. These entities will be among the few organizations in the world to have completed the budgeting and permitting for this type of activity.

Q. Does the work you have just described reflect the second step that you described above?

A. Yes, although not in great detail.

Q. What would the third step involve for PMEC?

A. This is a difficult question to answer because of the many unknowns involved. Site selection and accompanying engineering and economic evaluations for facility siting are fairly straightforward. However, because there is currently not a procedure in place to permit a sequestration facility the amount of data that will need to be collected for an EIS is unknown.

KIRKPATRICK & LOCKHART
PRESTON GATES ELLIS LLP
925 FOURTH AVENUE
SUITE 2900
SEATTLE, WASHINGTON 98104-1158
TELEPHONE: (206) 623-7580
FACSIMILE: (206) 623-7022

Legal issues associated with mineral rights or the equivalent, land ownership, and public acceptance introduce another level of complexity. Furthermore, long-term liability issues are as yet unaddressed and could potentially create yet another significant roadblock. As a result, it is impossible to say how long this process will take. As the US continues to move toward a carbon constrained economy much of this uncertainty will be reduced. What is clear, is that after the first two "steps" in this process Energy Northwest will have to evaluate all of the information collected to date and determine if full scale sequestration has become possible. There is the likelihood that after the first two "steps" in the evaluation process that no acceptable sequestration is identified in the area proximal to the PMEC. This is the reason why I would not recommend a rigid program which requires full scale sequestration after the first two steps. It may be that Energy Northwest would have to look farther afield for an acceptable sequestration site.

Q. Do you anticipate that Big Sky will be involved in this work?

A. I believe that it would be beneficial for Energy Northwest to participate with the Big Sky Partnership in this activity. However, this decision is not mine to make and can only be made by the partnership's director.

Q. Energy Northwest has budgeted $10 million to evaluate the potential for on-site or near-site sequestration of CO_2 captured at PMEC. Do you believe this is a sufficient amount to complete

A. I am currently involved in a very similar study at a different site in Washington State. Based on this study I believe that $10 million is sufficient to do the evaluation as described above. It is important to note that this $10 million is being spent on an evaluation process and will not be sufficient to have a facility ready to take carbon dioxide. I would recommend that

KIRKPATRICK & LOCKHART
PRESTON GATES ELLIS LLP
925 FOURTH AVENUE
SUITE 2900
SEATTLE, WASHINGTON 98104-1158
TELEPHONE: (206) 623-7580
FACSIMILE: (206) 623-7022

Energy Northwest follow closely the FutureGen project to get an idea of the level of commitment required to inject several million tons of carbon dioxide each year.

Q. Does this complete your testimony?

A. Yes it does.

EXHIBIT LIST

Ex. No.	Prefiled No.	Description
	TLM-1	Resume of Travis Lynn McLing

KIRKPATRICK & LOCKHART
PRESTON GATES ELLIS LLP
925 FOURTH AVENUE
SUITE 2900
SEATTLE, WASHINGTON 98104-1158
TELEPHONE: (206) 623-7580
FACSIMILE: (206) 623-7022

Figure 1: Secondary Mineral Formed in Mineral Trapping Sequestration

KIRKPATRICK & LOCKHART
PRESTON GATES ELLIS LLP
925 FOURTH AVENUE
SUITE 2900
SEATTLE, WASHINGTON 98104-1158
TELEPHONE: (206) 623-7580
FACSIMILE: (206) 623-7022

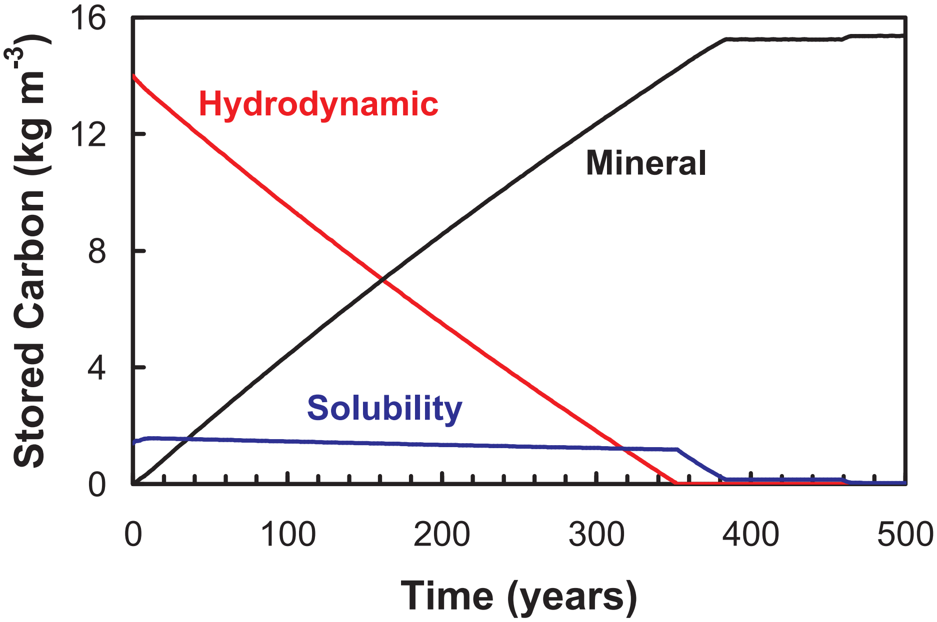

Figure 2: Mineral Trapping Reaction Time

KIRKPATRICK & LOCKHART
PRESTON GATES ELLIS LLP
925 FOURTH AVENUE
SUITE 2900
SEATTLE, WASHINGTON 98104-1158
TELEPHONE: (206) 623-7580
FACSIMILE: (206) 623-7022