

Carbon Dioxide Capture and Storage - Norwest's Know-How

by Jim Thomson, John Wright and Eduardo Manrique

Recent Norwester articles have described the synergy developed through the merger of Norwest, Applied Hydrology, and Questa Engineering, creating a high-level one-stop-shop for energy, mining, and environmental projects. Last year saw the intersection of our integrated services on many projects. In particular, we have recently pulled our varied technical strengths together to address the rapidly-increasing global interest in carbon dioxide (CO₂) capture and storage (CCS). The lead Norwester article in October 2005 predicted that this sector would represent a growing business opportunity, and indeed we are now actively involved in several projects that address this issue.

Because the goal of CCS is to prevent adding CO₂ to the global atmosphere, many practical options involve geologic storage ("sequestration"), as shown in the figure. In fact, geologic storage is the cheapest component of CCS, with capture and transportation being the most significant cost elements. Each of the four options shown in the figure, i.e. depleted oil/gas reservoirs, enhanced oil and gas recovery, deep saline formations, and enhanced CBM recovery (in approximate order of feasibility), all represent variations on mining and energy projects that Norwest has successfully performed over and over again. The technical ingredients include resource evaluation and appraisal, reservoir modeling, hydrogeologic evaluation, and permeability testing.

Perhaps the most obvious storage options (and the most mature technologies) are depleted reservoirs and enhanced recovery, which in a sense are recycling

the carbon back to where it originated. In these cases, feasibility analysis for CCS follows the same approach Norwest already follows in numerous enhanced oil and gas recovery (EOR/EGR) projects. While less developed, however, the largest disposal sites are deep sedimentary basins, frequently the same basins that have already been intensively studied by Norwest for coal, bitumen, oil, and gas resources. In these basins, the storage targets are permeable saline aquifers, and here our expertise in aquifer assessment and analysis comes to the fore. All CCS studies rely on the bedrock of sound geologic modeling which Norwest has demonstrated in resource evaluations around the world.

Given our technical strengths and ability to integrate them, it is not surprising that in the last three months we have been asked to assist in several major projects (many of which are confidential) to help identify, assess, and engineer CCS in the US and Canada. One of these projects is associated with a planned oil recovery project, while the other is involved in finding solutions for disposing of CO₂ from a planned Integrated Gasification Combined Cycle (IGCC) power plant. In the IGCC project, the full range of geological sequestration options is being investigated, with the application of CO₂ enhanced oil recovery in existing fields being the sequestration option of most interest. Even with that option, it appears that deep

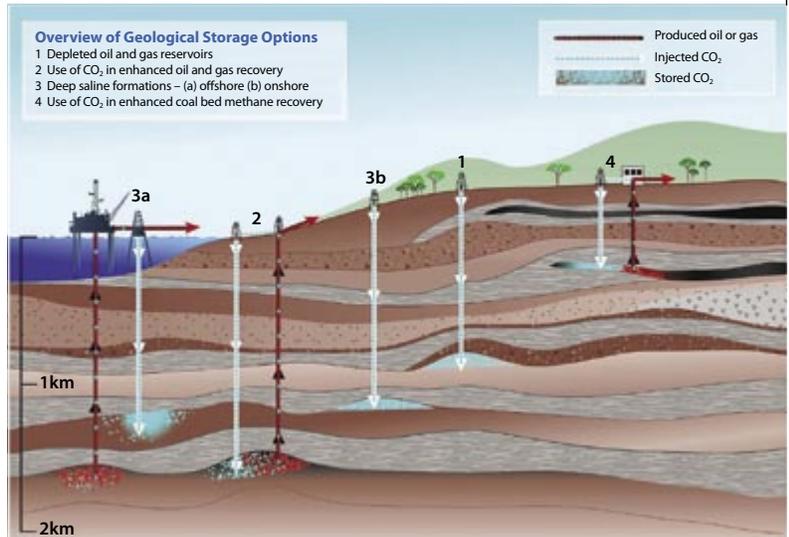


Figure Source: IPCC Special Report on Carbon Dioxide Capture and Storage (www.ipcc.ch)

saline aquifers will be required to achieve the desired amount of CO₂ sequestration. As the project moves into the permitting stage in the fall of 2007 Norwest will be in the forefront of designing and testifying about sequestration options.

Finally, there is no doubt that the oil and gas industry and the utility sector will work either independently or in combination to integrate multidisciplinary efforts to identify and optimize CO₂ sequestration options. These efforts will help to define carbon trading markets and to create

.....cont'd on Page 2

inside



- The Sarshatali Coal Mine..... > p2
- My House > p3
- International Economic Treaties > p3
- Presidents' Column > p4
- My, What Large Eyes You Have > p4
- Norwest-Questa Courses > p5
- From The Riddle Master > p5
- Norwester Loves to Educate... > p5
- Championships 2007 Mining Games > p6

The Sarshatali Coal Mine - Now Almost Five Years Old

by Andrew Scrymgeour

Ever since initial discussions in 1993, Norwest has been closely associated with the Sarshatali Mine located about 230 kilometres from Kolkata, India. The mine which is owned by Integrated Coal Mining Limited (ICML), a subsidiary of the electricity producer, CESC Limited, started up in mid-2002 and currently produces about 3 million tonnes per year through a mining contractor.

Norwest's involvement initially consisted of mining and coal washing feasibility studies – this intensified when we were awarded a five-year contract in mid-2002 to be ICML's "Owner's Engineer". During the first year of operation - the critical startup period - two Norwest staff members were assigned to the mine on full-time basis to perform mine planning and assist with the mine operation. In addition, intensive training in geology, environmental compliance and safety was conducted for the staff of both ICML and the contractor. Since that time, Norwest has gradually reduced its involvement to the

point where it now consists principally of periodic mine planning combined with safety and operational audits and associated training.

To reduce the ash content (typically +40% in-situ) of the as-shipped coal without mechanical washing, Sarshatali uses "selective mining" to remove high ash bands. CESC is very satisfied with Sarshatali coal and cite the following

7-cubic metre excavator loading 50-tonne.



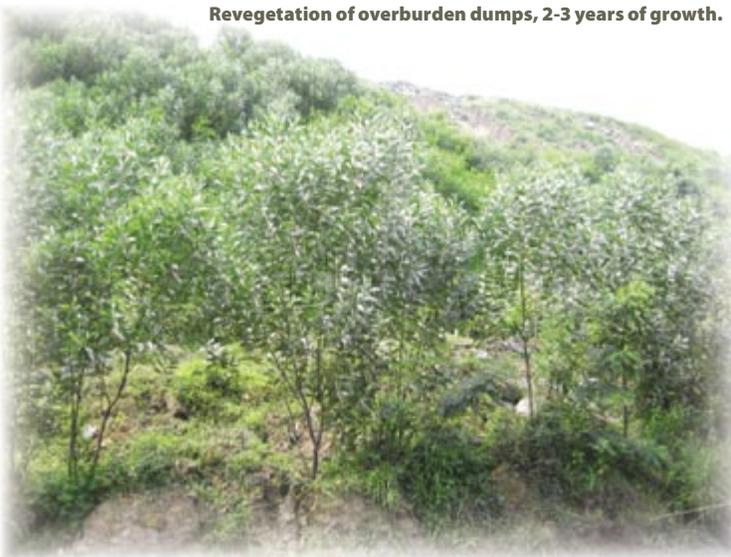
Vegetarian lunch in the making at the office canteen.

major results: reliability of supply - even through the monsoon; consistent sizing; reduced foreign material and crusher/mill maintenance; and improved plant uptime.

In addition to meeting all production targets, Sarshatali is rightly proud of its safety record and has consistently won important trophies in competitions organized by the Directorate General of Mine Safety, the government organization responsible for mine safety.

Andrew Scrymgeour
VP International Projects, Salt Lake City, UT
Tel: 801 539 0044 or ascrymgeour@norwestcorp.com

Revegetation of overburden dumps, 2-3 years of growth.



cont'd from Page 1: Carbon Dioxide Capture and Storage - Norwest's Know-How

the necessary regulatory framework. However, it is important to recognize that economic and legal issues are not the only challenges facing CO₂ sequestration projects. Identifying geologic sinks that can safely store CO₂ over geologic periods of time, "economically" capturing and disposing large amounts of CO₂ generated from various industrial sources (especially from power generation plants), and demonstrating to the public that this can be done safely, are among the most challenging tasks addressing CCS projects. In future Norwesters we look forward to describing more about our activities in this important, technically-demanding, and exciting field.

Jim Thomson, Senior Hydrogeologist, Denver, CO
Tel: 303 782 0164 or jthomson@norwestcorp.com
John Wright, President, Norwest-Questa, Golden, CO
Tel: 303 277 1629 or jwright@norwestcorp.com
Eduardo Manrique, Sr. Reservoir Engineer, Golden, CO
Tel: 303 277 1629 or emanrique@norwestcorp.com

My House

by Jodi Walter

I have worked a part time position for Norwest-Questa for six years. The flexible schedule allowed me to follow my real passion. I have a vision for reaching out to women diagnosed with breast cancer. This vision was a gift to me from the Lord and I need to give the gift away.

I founded MY House, a non-profit, 501 (c) 3, organization in 2002. MY House reaches women diagnosed with breast cancer and undergoing treatment. A day retreat is offered to the women in a home environment. Services include a massage, mini-manicure & pedicure, and a gourmet lunch for a time of sharing.

The services are complimentary and provided by women volunteers. Women facing breast cancer have a long journey, medically and emotionally. We provide a "rest stop" along the way.

We are purchasing a secluded lake cottage for the sole purpose of MY House which will allow us to reach more women. To raise funds for the house we are having a campaign called "One Brick at a Time". Bricks are sold in different denominations and sizes. The donor can inscribe an encouraging thought, the name of a corporation, or a "celebration" of life for a breast cancer survivor. The bricks will be used to make pathways in the gardens. Find out how you can participate in the campaign and more about MY House by visiting www.myhouse-myrefuge.org

I want to thank Norwest for allowing me to share MY House with you.



The day of signing on the new "My House". This picture is on the deck at the lake cottage which looks out on the lake. Some of the volunteers shown are: Top Row - Left to Right: Allison Pruett, Sarah Mihalcen, Jennifer Shelton, Traci Grubb, Linda Home; Bottom Row - Left to Right: Katie Withers, Lelienthal, Peter Lelienthal (seller), Jodi Walter, Jim Winsor (realtor).

Jodi Walter, Accountant, Golden, CO
Tel: 303 277 1629 or jwalter@norwestcorp.com

International Economic Treaties

Disputes involving international treaties between companies and governments are resolved through special tribunals designed to protect the economic interests of the parties. Only the top tier of international law firms is capable of dealing with such tribunals. Norwest was recently called in to provide expert litigation assistance to such a law firm involving a dispute relating to a major power project in a foreign country. In recent years Norwest has become increasingly involved in mining-related legal matters.

During the 1990s, the government of an Eastern European country induced power companies to develop new coal-powered electric generating plants with associated coal mines. A partnership between a US power company and coal company was sufficiently interested in the economic opportunity and invested substantial capital in a certain project. However, by the end of the century the

government introduced new policies favoring indigenous developers over international companies

The partnership found their project in serious jeopardy. Prior environmental permits were ignored, treasury guarantees withdrawn and fully-negotiated long-term off-take agreements disputed. It became clear the government wanted to take over the project for its own purposes. The partnership filed a claim before the International Centre for Settlement of Investment Disputes.

Norwest was pleased to play a significant role in bolstering the claimants' case. The team of Conrad Houser and Andrew Scrymgeour examined engineering and cost studies and other documents, prepared drafts, and consulted with counsel. Norwest opined the mine was both well-designed and economic and rebutted the government's claims that it was

technically impossible and economically infeasible.

Five years after the original claim was filed, the arbitration tribunal consisting of judges from three different countries, conducted hearings at the World Bank's headquarters in Washington, D.C. Following review of thousands of documents, a flurry of motions, and testimony from dozens of witnesses including Norwest, the tribunal awarded the partnership most of its lost investment and a significant portion of attorneys fees and costs. The partnership was gratified by the win.

Norwest is currently assisting in a similar 'takings' action based on the North American Free Trade Agreement. We are confident that Norwest's expert rebuttal reports will reduce the defendant's damages, if any there be.

Con Houser
Tel: 801 539 0044

Presidents' Message

The Greening of Planet Earth?

In recent months there has been a dramatic shift in the extent and nature of debate around the issue of climate change (aka global warming) in the media, the political arena and industry. Al Gore's documentary, *An Inconvenient Truth*, recently recognized at the Academy Awards, could be seen as part of the initial wave of heightened awareness in the public domain. But the topic is currently the subject of extensive media coverage and political debate in North America, the source of a significant portion of the green house gases (GHG) generated by mankind. This newfound popularity of "green" has manifested itself in new legislation, such as recently enacted auto emission standards in California (some of which are being quickly adopted in other jurisdictions).

There seems to be a general acceptance, even within the energy industry, that there is evidence that human-generated GHG may be playing a role in climate change. However, there is not a broad consensus on the magnitude of both that role and the extent to which climate change is outside "normal" or "natural" variability. The long term impact of climate change, in the most extreme case, could be

global environmental and economic devastation, and possibly the demise of the human race. The other end of the spectrum of possibilities could result in only minor climatic changes around the globe, with mankind adapting fairly easily.

Overlying the concerns related to climate change are a number of other factors, including the concentration of conventional petroleum reserves in areas that are considered politically unstable or unfriendly, and the aspirations of the developing nations to improve their living standards. How should we respond to this climate change challenge? Given the uncertainty of the outcome, it may be prudent to develop some strategies to modify our consumption of energy on a global basis.

The "easy" solution, widely touted in the public domain, is to replace fossil fuels (oil, natural gas and coal) in our energy mix as quickly as we can. The energy contribution of fossil fuels would be eliminated through a combination of energy efficiency, renewable energy, hydrogen and nuclear energy. This approach ignores the numerous technical, economic and social challenges associated with every one of the energy options. For example, the

"not in my back yard" (NIMBY) syndrome is a significant obstacle for the siting of nuclear plants, and even renewables, with wind farms recently facing local opposition in parts of Ontario.

The "easy" solution also ignores the abundance of fossil fuel energy resources in the world, and the development of new technologies that will enable us to effectively use those resources with minimal environmental impact. As key stakeholders in the outcome of the debate, we need to stay engaged. We need to do our part to ensure that people understand the contribution that fossil fuels can make to a healthier environment, the role that fossil fuels can fulfill in the overall energy mix, and the viable options to the "easy" solution.

We have a choice. As an industry, we can accept that there has been a fundamental shift toward "green" in society and actively support, develop and foster innovative technologies that deliver energy efficiency and GHG reduction, such as new "cleaner" combustion technologies and CO₂ sequestration. Or we can carry on with "business as usual" in the hope that this will all go away. My vote is for the former.

Joe Aiello, President, Norwest Corporation, Canada
 Bob Evans, President, Norwest Corporation, USA
 Donovan Symonds, Chairman, Norwest Corporation
 John Wright, President, Norwest-Questa Engineering, USA
 Mike Day, President, Norwest-Applied Hydrology, USA

My, What Large Eyes You Have!



What the heck is that? This little fellow with the enormous eyes and long feet is a Tarsier. At a mere 15 cm in height they are reputed to be the world's smallest primate. The average adult is about the size of a human fist. Native to several islands in Southeast Asia, I was lucky enough to see these adorable creatures first hand on the Philippine island of Bohol last year. Since they are nocturnal, tarsiers don't move around much during the day. This allows you to observe them up close while they are subdued and still. I saw several of these endangered animals at a sanctuary where they are protected and studied.



Gordon Daniel, Mining Engineer, Calgary, AB
 Tel: 403 205 5781 or gdaniel@norwestcorp.com

Norwester Loves to Educate the Masses

by Geoff Harding



Geoff prepares his fossil displays and activities with the Canmore scenery in the background.

As part of Calgary's field services and data development group for the past 3 years, one can really collect a lot of kid friendly stories to bring into many Alberta classrooms. Geoff Harding has now been involved with educational development and delivery for over 10 years, and he keeps collecting good stories including a resurging Mount St. Helens; New Mexico unexpectedly in the the snow; and, explorations of frontier Alberta and Saskatchewan oilsands. With a few years of refining his skills at the world renowned Royal Tyrrell Museum, Geoff brings into the classroom a sense of what can ignite a child's curiosity. He then introduces some more complex concepts in a simple but fun manner to enrich their experiences with Geoscience learning. This past fall a group of fellow APEGGA (Association of Professional Engineers, Geologists, and Geophysicists of Alberta) educators got together to build Outreach activity ideas that were eventually shared at

the Canmore Museum Open House. A casting workshop was held after which many families left with their fossil souvenirs they had helped discover. Earlier in 2004, Geoff was able to play the part of a rock star when he hosted "The Rock n Fossil Road Show" (an APEGGA, SciQ, AccessTV-CLT, and GSC sponsored project). He also wrote the popular kids program that became a highlight online learning tool in Cretaceous Crime Scene <http://www.learnalberta.ca/content/seccs/index.html?launch=true>. The program runs on-site at the Tyrrell Museum's new distance capable Learning Centre. Chapter 2 is now under development with more focus on oilsands suspects and heroes. The activities allow kids to play different character roles and investigate crime and reality from the Cretaceous period that is revealed in present day mining and in situ projects.

For further information on APEGGA's Outreach Program please visit <http://www.apegga.org/K12/outreach/toc.html>.

Geoff Harding, Geologist, Calgary, AB
403 268 6541 or gharding@norwestcorp.com



Strange Signpost

How far should it be to Vancouver on this strange signpost?

Salt Lake City	570
Calgary	360
Denver	300
Golden	300
Vancouver	??

Be one of the next five lucky winners:

Five winners will be drawn from all those with correct responses submitted to Theresa Murphy by September 30, 2007.

Norwest-Questa Courses

CBM Operations - Focus Canada

April 24, 2007, 8:00am-5:00pm
Calgary, AB - Telus Convention Centre

Oil Field 101™ An Introductory Course for Non-Technical People

May 1-2, 2007, 8:00am-5:00pm
Golden, CO

Coalbed Methane Technology And Practices NEW IN SPRING 2007

Module #1:

May 14, 2007, 8:00am-5:00pm, Golden, CO
CBM Geology & Case Studies

Module #2:

May 15, 2007, 8:00am-5:00pm, Golden, CO
CBM Reservoir

Module #3

May 16, 2007, 8:00am-5:00pm, Golden, CO
CBM Simulation

Module #4:

May 17, 2007, 8:00am-5:00pm, Golden, CO
CBM Drilling and Completions

Module #5:

May 18, 2007, 8:00am-5:00pm, Golden, CO
CBM Production and Project Development

For further details, email
questa@norwestcorp.com OR 303 277 1629.



November 2006

"The Painting"

1,106. The Roman numerals in each name are added together.

The winners from last issue's riddle were:

Peter Armstrong, Victoria, BC, CANADA
Denise Canfield
Eric Huelson, Golden, CO, USA

Congratulations to all the participants and winners who demonstrated their abilities in problem solving and having fun with last issue's "monthly riddle." A job well done!

Champions 2007 Mining Games



To Norwest,

On behalf of the 2007 University of Alberta Mining Games team, I would like to pass along our gratitude for your sponsorship. We really appreciate the contributions that the industry has made to us as students, and especially to this cause. We have now returned from Montreal, where we were victorious. We placed first overall for the event beating out the 9 other mining universities who each put up a fierce competition. The weekend was a huge success, with many high ranking finishes in individual events, and culminating with the top place finish for the University of Alberta. While the weekend was filled with competitions to test our skills, knowledge, and even our strength, there were many networking opportunities for participants to make valuable contacts, and forge new friendships. As a small token of our appreciation, please find attached a photo of the winning team with the championship trophy on display.

Thank you again for your generous contribution, without sponsors such as yourself, events like this would not be possible.

Grant Lankhaar

2007 University of Alberta Mining Games Team Captain

for more information on:

NORWEST
CORPORATION

CANADA

Calgary, Alberta

Tel: 403 237 7763 Fax: 403 263 4086
Email: calgary@norwestcorp.com

Vancouver, British Columbia

Tel: 604 602 8992 Fax: 604 602 8951
Email: vancouver@norwestcorp.com

USA

Charleston, W. Virginia

Tel: 304 414 4500 Fax: 304 414 4505
Email: charleston@norwestcorp.com

Denver, Colorado

Norwest-Applied Hydrology International
Tel: 303 782 0164
Email: appliedhydrology@norwestcorp.com

Gillette, Wyoming

Tel: 307 685 3044 Fax: 307 686 0880
Email: gillette@norwestcorp.com

Golden, Colorado

Norwest-Questa Engineering Corporation
Tel: 303 277 1629 Fax: 303 277 0119
Email: questa@norwestcorp.com

Grand Junction, Colorado

Tel: 970 245 6552
Email: grandjunction@norwestcorp.com

Houston, Texas

Tel: 281 333 2241 Fax: 281 333 1192
Email: houston@norwestcorp.com

Pittsburgh, Pennsylvania

Tel: 724 255 9905 Fax: 724 225 9903
Email: pittsburgh@norwestcorp.com

Salt Lake City, Utah

Tel: 801 539 0044 Fax: 801 539 0055
Email: slc@norwestcorp.com

Trinidad, Colorado

Email: trinidad@norwestcorp.com

Yerington, Nevada

Tel: 775 463 9388 Fax: 775 463 9488
Email: yerington@norwestcorp.com

INTERNATIONAL

Beijing, China

Tel: +86 10 6466 4848 Fax: +86 10 6466 7489
Email: guojiuhong@norwestcorp.com.cn

Newcastle, NSW

Tel: + 61 02 4975 5228 Fax: + 61 02 4975 5220
Email: australia@norwestcorp.com

Kolkata, India

Tel: 91 33 449 9550 Fax: 91 33 449 1494

NORWESTER

EDITORS

Theresa Murphy

Tel: 403 237 7763
Email: tmurphy@norwestcorp.com

NORWEST
CORPORATION

David Wright

Fax: 403 263 4086
Email: dwright@norwestcorp.com



*is a publication for the
employees, clients and friends
of Norwest Corporation.*