The De Beers Gahcho Kué Project Joint Venture

Dewatering Experience, Winter 2014-2015

Nathan Schmidt, Golder Associates Ltd.

De Beers Group of Companies

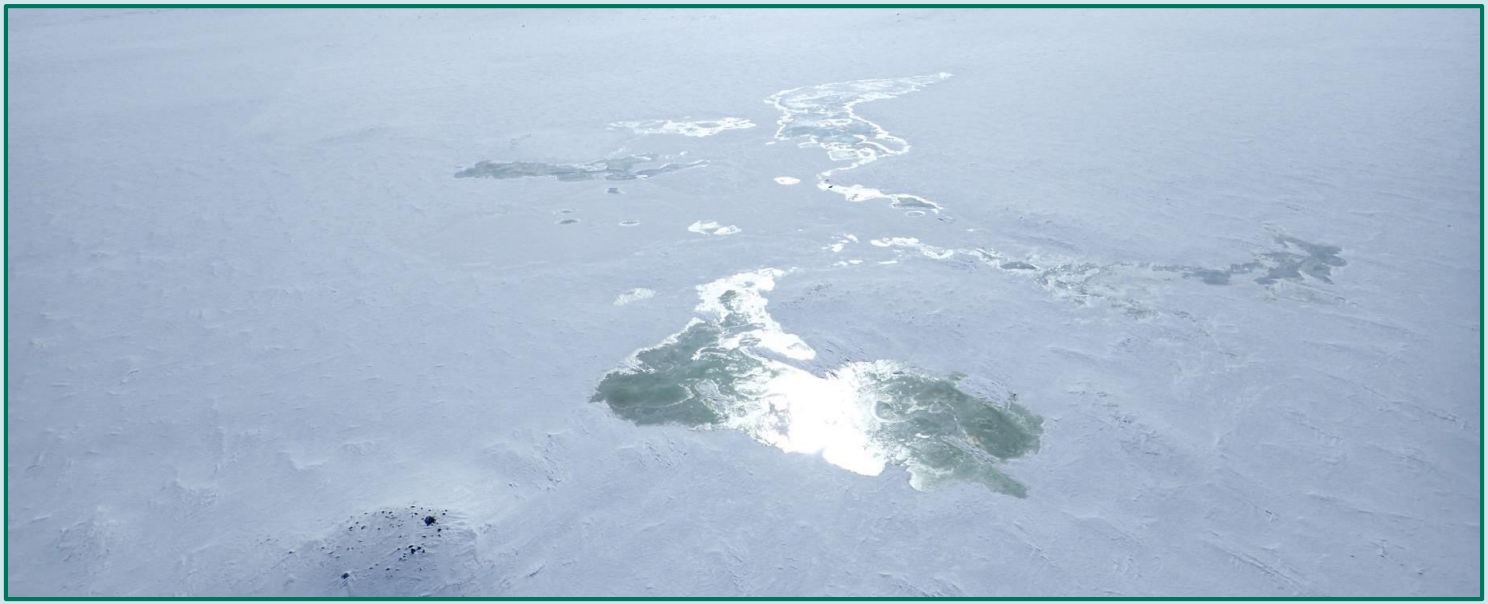
Golder Associates

Gahcho Kué Project – Winter Dewatering 2014/15

Thanks to:

Patrick Kramers, Veronica Chisholm, Allan Rodel & Andrew Williams - De Beers Group of Companies

Tim Ensom, Dave Casson, Charity Beres, John Faithful - Golder Associates Ltd.



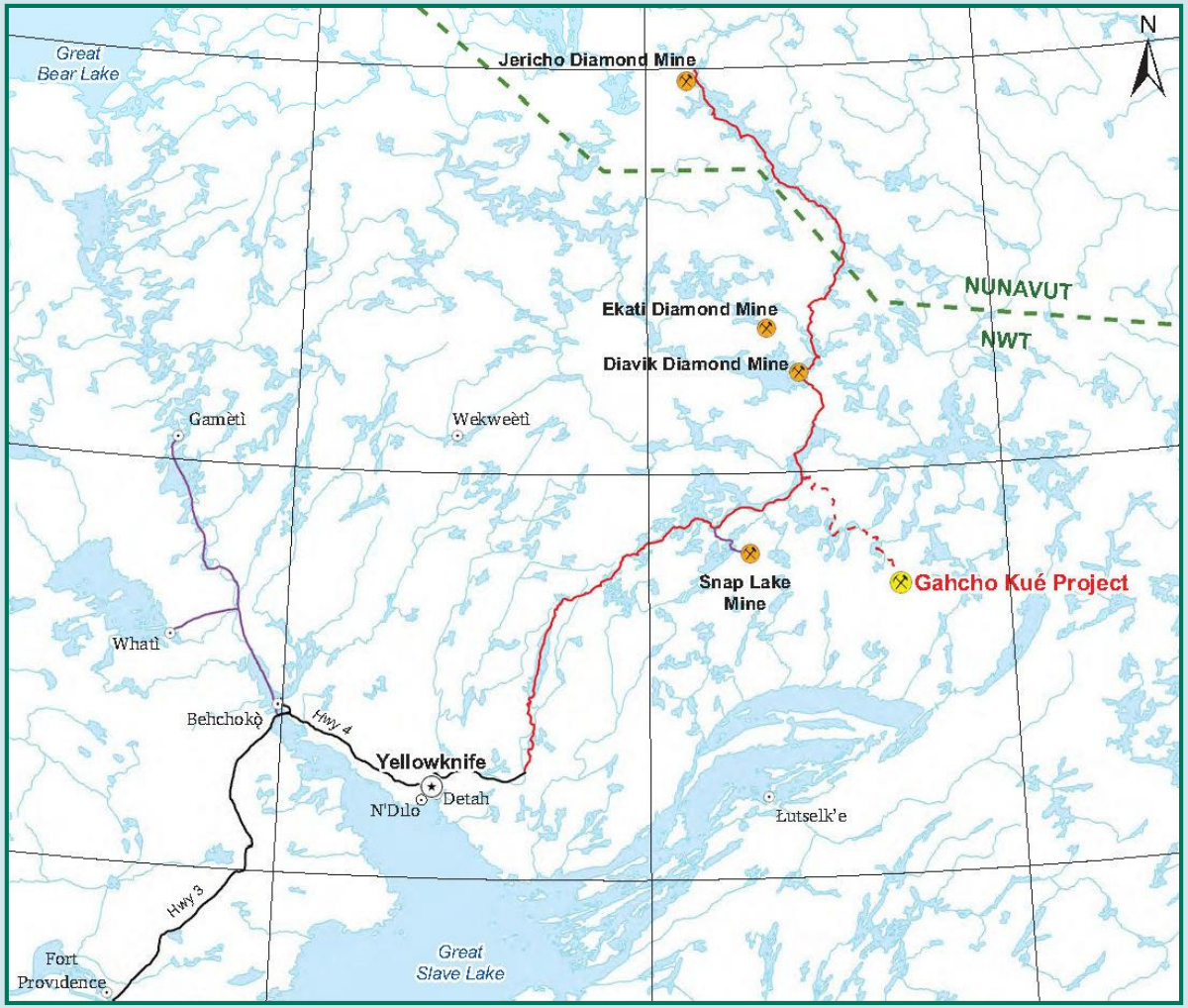
De Beers Group of Companies

Golder Associates

Gahcho Kué Project – Winter Dewatering 2014/15

- 280 km northeast of Yellowknife
- Joint Venture between De Beers Canada (51% - the Operator) & Mountain Province Diamonds (49%)
- 3 kimberlite pipes to be mined via open pit
- Mine Life ~12 years
- Average annual production: ~4.5 million carats
- ~$1B capital cost
- Operational workforce of ~400

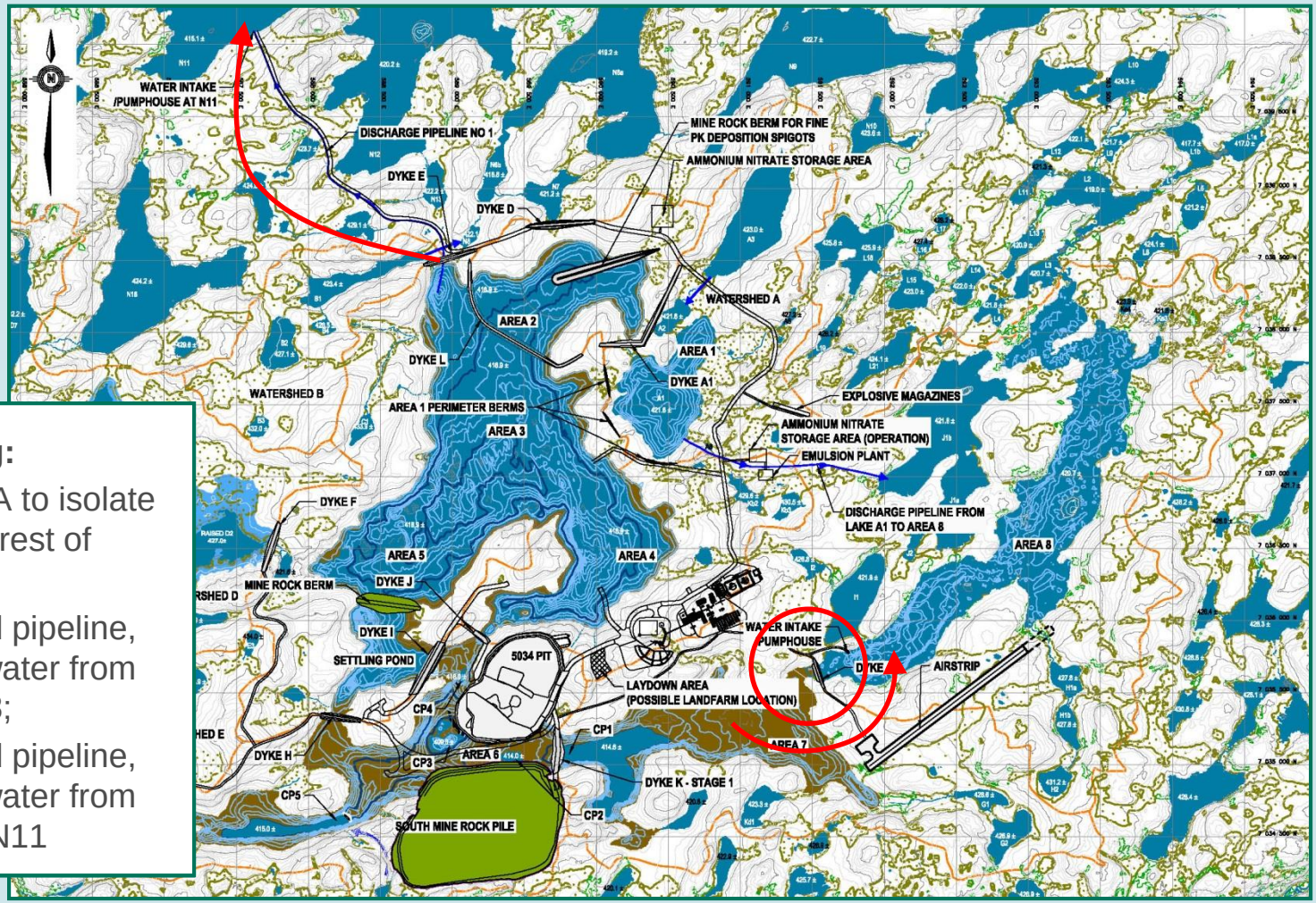
Gahcho Kué Project - Winter Dewatering 2014/15



De Beers Group of Companies

Golder Associates

Gahcho Kué Project - Winter Dewatering 2014/15



Stage 1 Dewatering:

- construct Dyke A to isolate Area 8 from the rest of Kennady Lake;
- install pump and pipeline, and discharge water from Area 7 to Area 8;
- install pump and pipeline, and discharge water from Area 3 to Lake N11

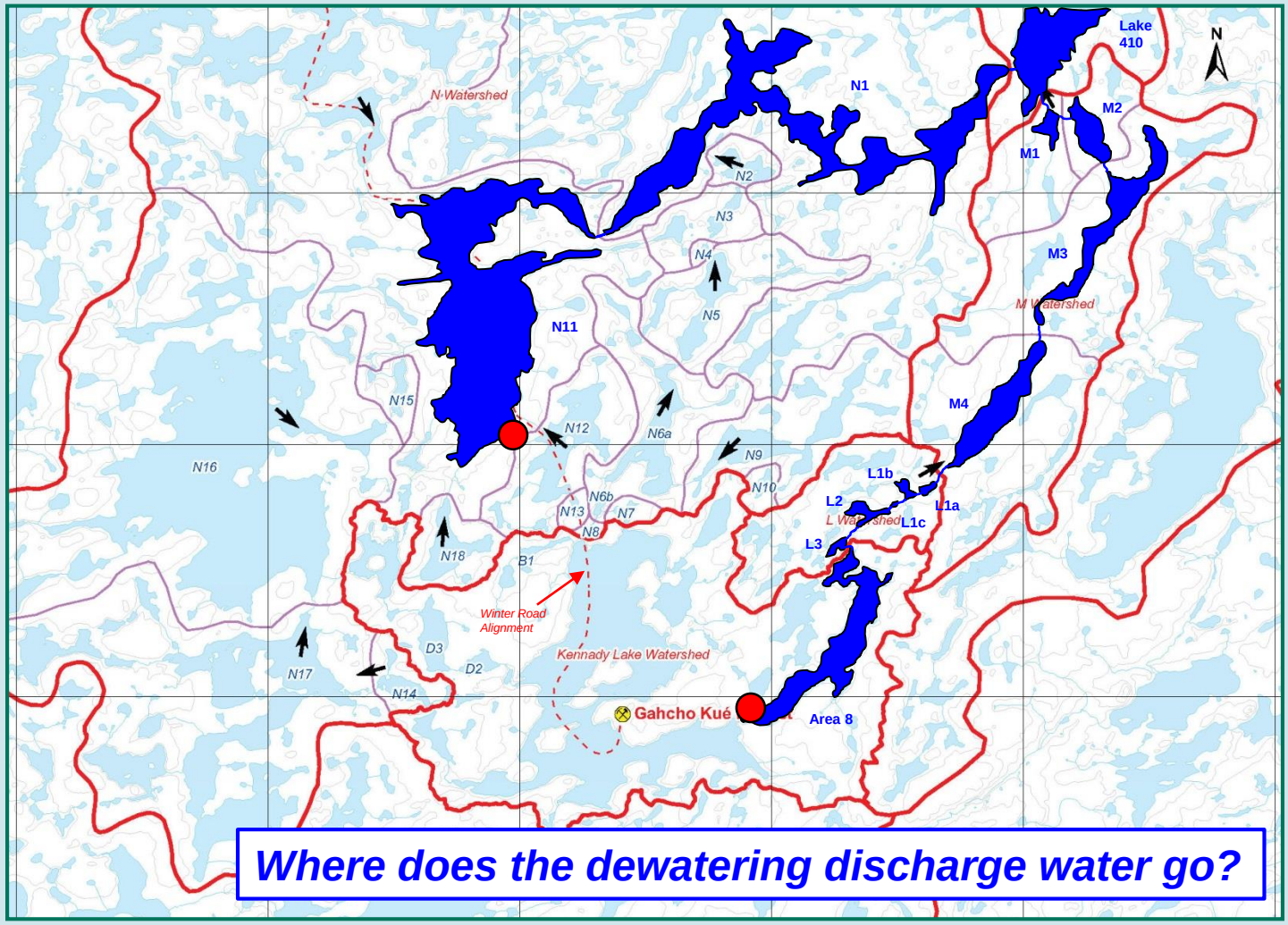
De Beers Group of Companies

Golder Associates

Gahcho Kué Project - Winter Dewatering 2014/15

- Open Water Dewatering Limits:
  - established during EIS
  - designed to protect the downstream environment from erosion during dewatering
  - total discharge limited to natural 2-year flood
  - 1.56 m^3/s (135,000 m^3/d) at Area 8
  - 6.00 m^3/s (500,000 m^3/d) at Lake N11
- Stage 1 Dewatering Objectives:
  - discharge 18.7 Mm^3 of water from Kennady Lake
  - maximum rate of 0.77 m^3/s (67,000 m^3/d) to Area 8
  - maximum rate of 1.50 m^3/s (130,000 m^3/d) to Lake N11
  - maximum rates were limited by system capacity, but adequate to meet project timelines

Gahcho Kué Project - Winter Dewatering 2014/15



De Beers Group of Companies

Golder Associates

Gahcho Kué Project - Winter Dewatering 2014/15

Why dewater in the winter?

- The regulatory process required the full review period.
- The Type A Water Licence for the Mine was issued on September 24, 2014
- Dyke A needed to be built before dewatering
- Without winter dewatering, construction would be delayed by over six months
- De Beers anticipated the need for winter dewatering and had introduced this during the regulatory process
- The Type A Water Licence included conditions on winter dewatering, as established in the Construction Water Management Plan and Aquatic Effects Monitoring Program

Gahcho Kué Project - Winter Dewatering 2014/15

Challenges with Winter Dewatering

- Need discharge water to be conveyed far downstream to free-flowing water bodies
- Ice dams at lake outlets could cause *aufeis* accumulations and increases in upstream water levels; adverse effects include:
  - Increasing spring freshet flood peak discharges
  - Constricting flow, increasing velocity / erosion potential
  - Diverting spring runoff along alternate routes, causing erosion and new channel formation
  - Forcing water into lake and channel banks and causing sloughing during melt
  - Thick channel ice deposits can adversely affect spring spawning fish

Gahcho Kué Project - Winter Dewatering 2014/15

Natural Freshet at Lake L1a Outlet: Bedfast Ice

Examples of Aufeis Effects

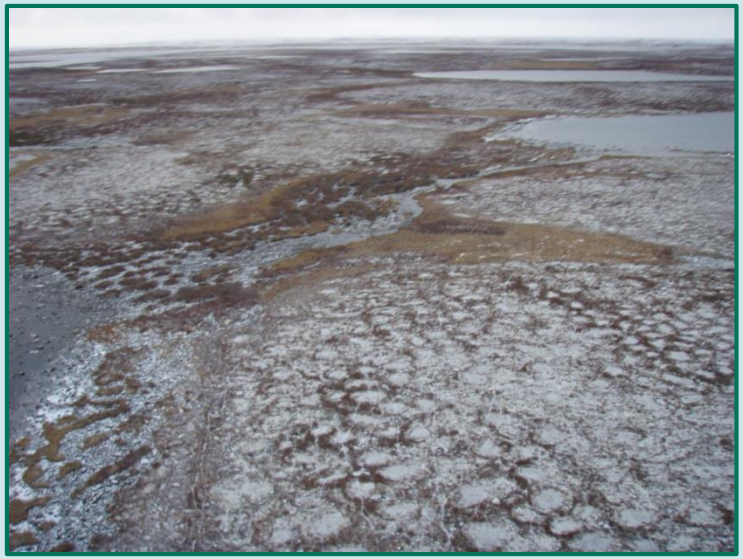
Example of Aufeis Deposit Concentrating Freshet Runoff (photo not taken at Gahcho Kué)

Gahcho Kué Project - Winter Dewatering 2014/15

Conditions at Gahcho Kué

- Lake outlet channels are typically broad and shallow, with low banks and in low relief topography
- Small drainage areas, particularly along the Area 8 flow path, mean the channels may freeze solid over winter

April 2014 – Snow Trench across Lake N11 Outlet



Broad Channel / Low Relief Terrain at Lake M4 Outlet

De Beers Group of Companies

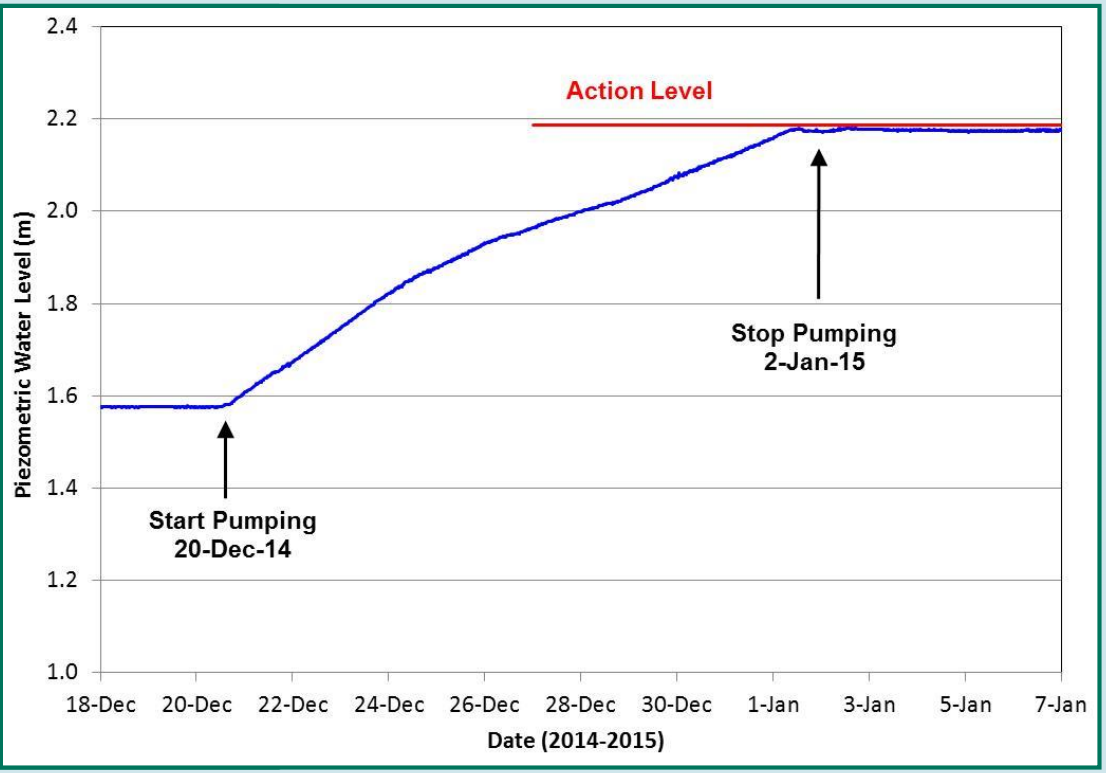
Golder Associates

Gahcho Kué Project - Winter Dewatering 2014/15

- Downstream Action Levels were established
- Pumping was to be suspended if hydrostatic water levels exceeded the 1:10 year flood level for a receiving lake
- A downstream monitoring program was developed:
  - Telemetry to measure water levels at Lake N11 and Area 8
  - Field visits to document ice and flow conditions at lake outlets down to Lake 410

Observations of Flow and Ice Conditions at Outlet *(circle letter below)*					
Open Water	Ice Covered Flow	Dispersed	Concentrated	Ice Covered Flow	Ice Covered
No Bedfast Ice	No Bedfast Ice	Open Water on Bedfast Ice		On Bedfast Ice	Frozen to Bed
					
A	B	C	D	E	F

Gahcho Kué Project - Winter Dewatering 2014/15

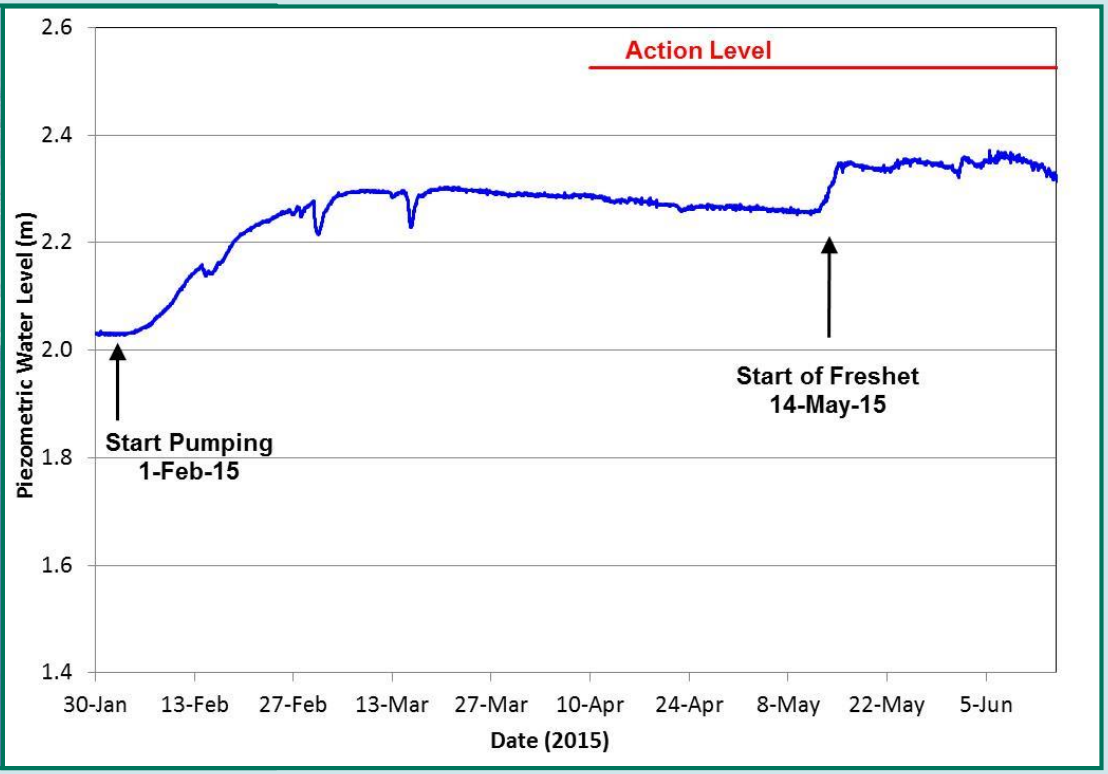


- Pumping was throttled back on 1 January and suspended on 2 January
- 778,745 m^3 of water was pumped over 13 days

De Beers Group of Companies

Golder Associates

Gahcho Kué Project - Winter Dewatering 2014/15



- Pumping continued through the early part of freshet (14 May 2015) and beyond
- 6,021,000 m^3 of water was pumped over 103 days

De Beers Group of Companies

Golder Associates

Gahcho Kué Project - Winter Dewatering 2014/15

Lake N11 Outlet
19 February 2015

Lake N11 Outlet
24 February 2015

Lake N11 Outlet
30 March 2015

Lake N11 Outlet
8 April 2015

De Beers Group of Companies

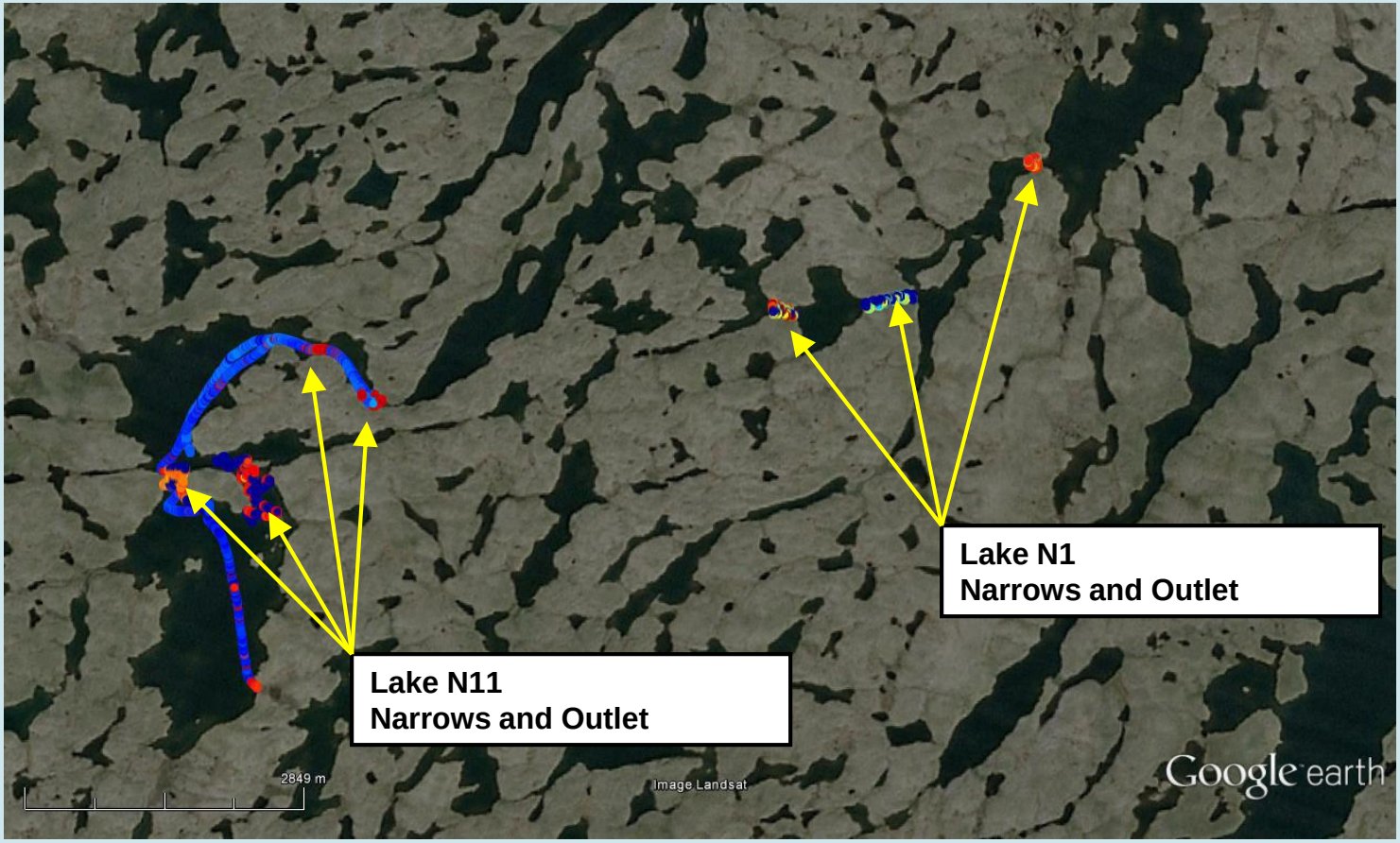
Golder Associates

Gahcho Kué Project - Winter Dewatering 2014/15

What else was going on downstream?

- Downstream observations focused on area from Lake N11 to Lake N1 outlet
- Field crews observed some staging up of Lake N1:
  - Concern about ice dam at outlet or at narrows
- Field crews observed thin ice in shallow/narrow areas within lakes:
  - Health and safety concern communicated to all field crews
- Ground Penetrating Radar surveys were performed to confirm ice dams were not forming at other locations

Gahcho Kué Project - Winter Dewatering 2014/15

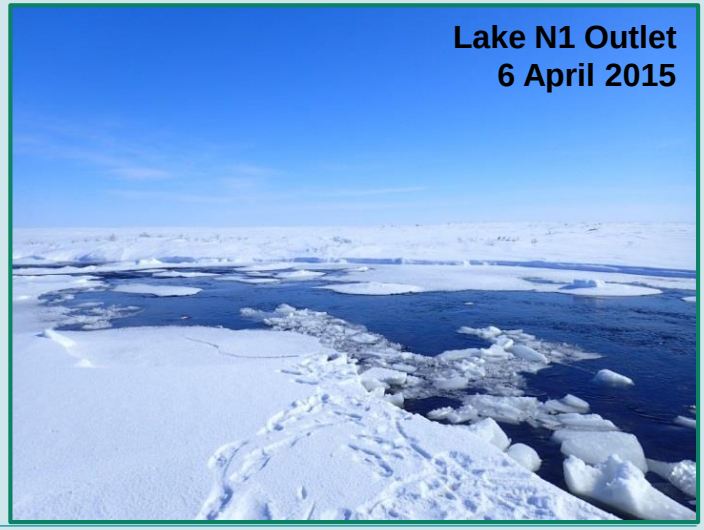


Locations of Ground Penetrating Radar Ice Thickness Surveys

De Beers Group of Companies

Golder Associates

Gahcho Kué Project - Winter Dewatering 2014/15



De Beers Group of Companies

Golder Associates

Gahcho Kué Project - Winter Dewatering 2014/15

- De Beers considered the risks associated with winter dewatering when developing the Construction Water Management Plan and Aquatic Effects Monitoring Program
- Dry conditions prior to dewatering at Area 8 were not favorable to conveying water downstream. All water discharged went into storage until spring freshet, and pumping was suspended as the action level was approached
- The larger watershed area at Lake N11 was more favorable to conveying water downstream, and dewatering flows were successfully conveyed downstream without exceeding action levels
- Surveys in summer 2015 confirmed no adverse effects to channel morphology

Gahcho Kué Project - Winter Dewatering 2014/15

- Factors contributing to the success of the winter dewatering program included:
  - Solid understanding of baseline hydrology
  - Solid understanding of winter flow mechanisms, potential effects and mitigation measures
  - Well developed water management planning including contingencies
  - Well planned and executed operational monitoring programs

Gahcho Kué Project - Winter Dewatering 2014/15

- *Project Overview*
- *Project Location*
- *Project Features*
- *Water Management*
- *Winter Dewatering Challenges*
- *Local Conditions*
- *Monitoring Plan*
- *Monitoring Results*
  - *at Area 8*
  - *at Lake N11*
  - *Downstream*
- ***Conclusions***

De Beers Group of Companies

Golder Associates