
**Testimony to Alaska House Natural Resources Committee
Oversight Hearing, Ambler Mining District Industrial Access Road**

Mr. Chairman, members of the committee, for the record my name is Kendra Zamzow. I am an environmental geochemist and a 30-year resident of Alaska. I work for the Center for Science in Public Participation. My role is primarily to review technical documents on mining projects and highlight potential risks for communities and tribes.

I look forward to seeing the Pre-Feasibility Study on the Arctic Project, which has not yet been released. This testimony is based on prior documents and news releases regarding the Pre-Feasibility study.

My conclusions are that it is much too soon for the State to invest in infrastructure. Exploration in the Ambler District has not yet achieved a level of confidence that mining could be conducted profitably on even a single, let alone multiple, ore deposits. I base this conclusion on the following:

- Not a single ore deposit has been shown to have “measured resources” or “proven reserves”, terms which provide a level of certainty that mining could be profitable.
- Drilling has been extremely limited. Much more extensive drilling, requiring years of work, will be needed to define the ore bodies and determine potential viability.
- Only one company is exploring the area, despite several known deposits.

Mineral Resources and Mineral Reserves

The area has rich deposits of copper and zinc, but these alone are not enough to state with confidence that mining can be conducted with a profit. The size, shape, and continuity of the ore bodies will strongly affect the cost of mining, as will the geology. The Arctic deposit is a massive sulfide style deposit, and as such material will go acidic upon weathering. This greatly increases environmental risk and the cost of managing waste storage; in particular it generally increases the cost of closure, which is important to consider when determining the actual profitability of mining.

When mining companies report to investors, the language they use reflects the modifying factors that place constraints on the viability of a profitable mine. Rich ore means they have a “Mineral Resource” – the level of confidence in how much rich ore they have in a condensed area is referenced using the terms “inferred”, “indicated” and “measured” mineral resources which reflect increasing confidence in a well-defined ore body. To date there are no “measured” resources – reflecting high confidence – at any deposit in the Ambler district.

Associated with the term “mineral resources” is the term “mineral reserves”. “Resources” shows the level of confidence in the ore body; “Reserves” is the level of confidence that the ore can be mined profitably. “Reserves” considers the many economic costs, such as providing power and infrastructure, as well as the cost of water treatment and closure. “Reserves” are either “Probable” or “Proven”. The Arctic “Pre-Feasibility Study”, which has not yet been released, will be the first document to state that there are “Probable Mineral Reserves”. Whether this label can be maintained will likely depend in part on whether the mining company or the State pays for the proposed Ambler Industrial Access Road.

This is my first concern: I would caution that even if the State pays for the road, without “Proven Mineral Reserves” the road could be in place and not a single mine would go in.

Exploration drilling

My second concern is the lack of effort in exploration. Between 2004 and 2017, less than 100 boreholes were drilled at the Arctic deposit and less than 60 at Bornite. Hundreds more will be needed to define the edges of the ore body and conduct “infilling” to determine the consistency, shape, and depth. These are the first steps to increasing the level of confidence in the deposit itself – regardless of economics – to “Measured Resources”, the term for a high level of confidence in the ore body. You can’t reach this level of confidence by drilling 5-7 boreholes per year, the effort expended by NovaCopper or Trilogy at the Arctic and Bornite deposits.

Trilogy’s effort is in strong contrast to other exploration areas that have shown promise. For example, at Donlin, Placer Dome had 2.2 million ounces of “Measured Resources” within 5 years of exploration; when NovaGold took over exploration at Donlin, they drilled over 200 boreholes per year between 2006 and 2008 to better define the ore body. At Pebble, Northern Dynasty had 5 billion lbs of “Measured Resources” within three years, and drilled an average of 135 boreholes per year between 2002 and 2008. This is the level of effort we would expect to see to

- a) Define the ore body and reach high confidence in “Measured Resources”
- b) Conduct the geotechnical work needed as the foundation for developing the mine design, which affects whether there can be a profitable mine, and lead to “Proven Reserves”

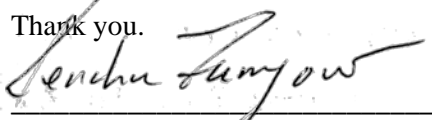
So my second concern is that the exploration work is proceeding at such an agonizingly slow rate that it could be decades before there is a well-defined ore body, and enough information to support a mine design. Again, the State should be extremely cautious about investing at this stage.

Exploration by other companies

AIDEA has stated a conceptual plan of four mines opening simultaneously in the Ambler District. I have noted the extremely limited drilling being conducted by Trilogy at the Arctic and Bornite deposits, and they are the only company exploring at all. As of late 2017, there has been no interest in exploring the Sun or Smucker deposits. Teck, which owns the Red Dog mine, has the Smucker mine. Despite the relative close proximity to Red Dog, they have shown so little interest in the deposit that it is not mentioned in its annual reports or on its website. The Sun deposit has changed ownership several times. One year after Andover Mining announced the deposit was in “advanced exploration”, the company went bankrupt (2014); the current owners have not conducted any exploration.

In conclusion, I would like to emphasize that rich ore does not necessarily make a mine. There has been far too little effort extended at the Ambler District, by Trilogy or other mining companies, to have any confidence that even a single mine, let alone several, will open. The State should wait until there are, at a minimum, “Measured Resources” at several mines and at best “Proven Reserves”. That would be the point at which to consider how infrastructure. It is simply much too early to invest in a road. The State would be taking too great a risk based on extremely limited information.

Thank you.



Kendra Zamzow, PhD
April 6, 2018

SUPPORTING INFORMATION

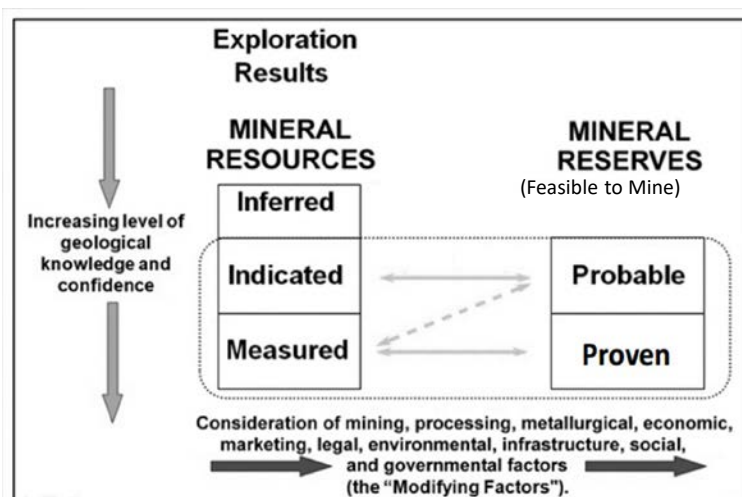
Information regarding Mineral Resources and Reserves

There are specific terms that are used to inform investors about the viability of an ore deposit (“Mineral Resources”) and the viability of mining that deposit (“Mineral Reserves”).

- **Inferred Mineral Resource:** low confidence
- **Indicated Mineral Resource :** moderate confidence
- **Measured Mineral Resource:** high confidence

In the EARLY stages of mining, exploration holes hit (or do not hit) pockets or veins of ore. From this, ore grade and locations can begin to be determined and lead to “inferred resources”. It generally takes years of additional drilling and hundreds of drill holes to move to increasing (or decreasing) confidence. This is the point where the edges of the ore body are determined, and “infilling” drilling is used to define the shape, depth, and continuity of the deposit, and further define the ore grades. It is during this period that exploration will either move increasingly towards or away from confidence in a mine.

Confidence in a mining prospect BEGINS with a well-developed ore body of sufficient grade and in a shape and depth that facilitates mining. Additional economics must also be taken into account, though. This includes the cost of providing power and infrastructure, as well as studies to determine the soil and rock layers in proposed tailings storage areas, how much it will cost to build the tailings storage facility, the specifics of processing the ore (which requires pilot testing), mine design, mining methods, and environmental studies. These are “modifying factors” that can make or break a project regardless of the confidence in the ore body.



- **Measured + Indicated Resource** tons and grade within the mine plan are converted to **Probable and Proven Reserves**.
- Measured and Indicated resource blocks OUTSIDE of the mine plan shapes are still reported as Resource

I do not address “Inferred Resources” here, as the term refers to resources so vaguely defined they cannot be used in investor statements. The “Indicated Resources” remained little changed between 2007 and

2017; there was a slight increase in volume of resources with a slight decrease in ore grade. To some degree the change is due to “re-assaying” old cores rather than finding additional ore through drilling. A significant increase in Indicated Resources at Arctic is expected in the Pre-Feasibility Study, based on news releases. However, the study itself has not been released or posted on the Canadian Securities and Exchange site (SEDAR, www.sedar.com) as of the morning of April 5, 2018.

Table 1. Indicated resources. The table shows the “Indicated Resource” amount and grade at the 0.5% cutoff grade and Net Smelter Return cutoff of \$35/t for the model shell. 2017 results are based on information from news releases. na= information not available Mlbs = million pounds Moz = million ounces g/t = grams per ton

Year		Arctic										
			Cu		Zn		Pb		Ag		Au	
	# holes	meters	Mlbs	Grade	Mlbs	Grade	Mlbs	Grade	Moz	Grade (g/t)	Moz	Grade (g/t)
Historic	92	16,080	na	na	na	na	na	na	na	na	na	na
2004-2006	32	9,126	na	na	na	na	na	na	na	na	na	na
2007	4	2,606	1,500	4.1%	2,200	6.0%	350	0.9%	32	59.6	0.5	0.8
2008	14	3,306	unchanged									
2009	0	0	unchanged									
2010	0	0	unchanged									
2011	5	1,193	unchanged									
2012	4	2,606	1,700	4.1%	2,500	5.8%	415	1.0%	37	unchanged		
2013	na	na	1,700	3.3%	2,300	4.5%	401	0.8%	41	53	0.55	0.7
2014	na	na	unchanged									
2015	14	3,056	unchanged									
2016	13	3,058	unchanged									
2017	5*	na	2,441	3.1%	3,356	4.2%	581	0.7%	55	48	0.73	0.6

*Five holes were drilled for an additional 790 m, but were not used for the resource estimate; they were to be used for “future metallurgical testing” (Trilogy Technical Report, November 2017, Section 10)

Year		Bornite		
			Cu	
	# holes	meters	Mlbs	Grade
Historic	na	47,531	41	1.4%
2004-2010	0	0	unchanged	
2011	14	5,819	unchanged	
2012	21	15,457	179	1.2%
2013	17	8,142	unchanged	
2014	0	0	334	1.1%
2015	0	0	unchanged	
2016	0	0	913	1.0%
2017	7**	8,437	pending	

**Nine holes were drilled but only 7 reached target depth; the remaining two will be finished in 2018

In order for there to be confidence in a viable mining prospect,

- An ore body needs to be defined as “Measured Resources”
- Resources need to be converted to “Proven Reserves”, which consider not only the ore body (grade, shape, etc.) but the economics of mining.

The Trilogy Pre-Feasibility Study is expected to convert Indicated Resources to Probable Reserves – that is, they will convert information from exploration that shows “moderate confidence” in the ore deposit to some probability that mining can be conducted economically. The terms Probable or Proven Reserves are meaningful to investors, and I show them in grey font until they are posted onto the Canadian SEDAR site.

Table 2. Probable and Proven Reserves

Year	Arctic Proven Reserves	Arctic Probable Reserves	Bornite Probable Reserves
2016	0	0	0
2017	0	43M tonnes Cu at 2.3%	0

Because these terms are important to investors, Trilogy cautions:

United States investors are cautioned not to assume that estimates of indicated mineral resources are economically minable, or will be upgraded into measured mineral resources. Trilogy. 2018. Annual 10K form.

For comparison, Placer Dome at Donlin had 2.2 million ounces of Measured Resources within 5 years of exploration.¹ Teck Cominco explored Pebble with about 25 exploration holes per year from 1986-1997; when Northern Dynasty Minerals took over in 2002, they had Measured Resources of 5 billion pounds of copper by 2005.²

Drilling is critical to this. What initially may look like a rich ore based on a few drill holes may turn out to be more complex and costly to mine once additional drilling is conducted. This is shown schematically and by a figure of copper grades in drill holes from Trilogy.

Figure 1. Drilling to define an ore body. The schematic is adapted from Lynn Canal Geologic Services; the isometric view is from the Trilogy November 2017 Technical Report.

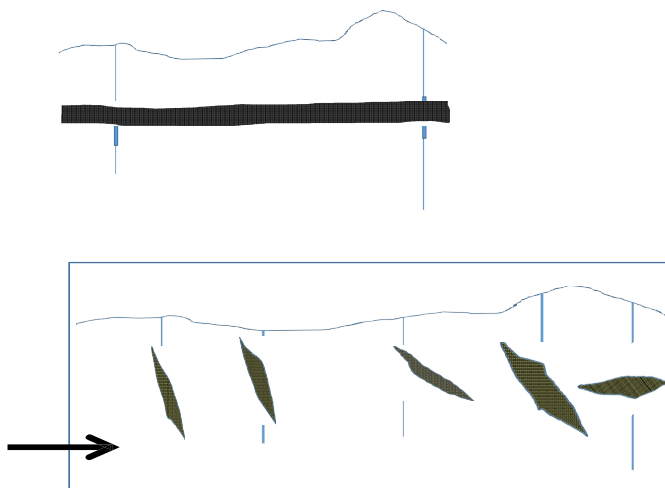
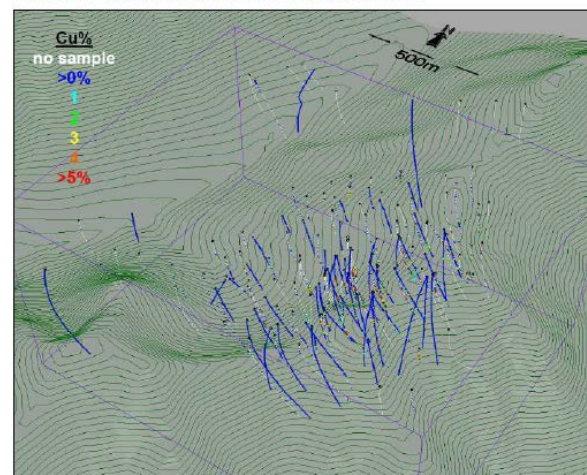


Figure 14-2 Isometric View of Copper Grades in Drill Holes



¹ SRK 2006

² Rebagliati and Payne 2004; Rebagliati et al. 2008

To get from Inferred to Indicated to Measured Resources requires drilling hundreds of holes. Without this, the nature of the deposit, the consistency of grade, the distribution and predictability of mineralization is not defined enough to have confidence in the ore body. To date, drilling by Trilogy has been very minimal at the Arctic and Bornite deposits. A comparison relative to known viable deposits is shown in Table 3.

Table 3. Comparison of drilling efforts at comparable mine stages. Drilling after 2008 at Donlin and Pebble has not been included in order to better show the comparison for drilling effort in reaching the stage of Measured Resources and Probable Reserves. Blue shading indicates drilling by the companies currently at the prospect.

	Bornite		Arctic			Donlin		Pebble	
Year	# holes	meters	# holes	meters		# holes	meters	# holes	meters
Historic	na	47,531	86	16,080		208	na	154	18,607
1995	na	na	na	na		32	na	0	0
1996	na	na	na	na		144	na	0	0
1997	5	928	0	0		118	na	20	4,479
1998	na	na	6	1,492		96	na	0	0
1999	na	na	na	na		33	na	0	0
2000	na	na	na	na		7	na	0	0
2001	na	na	na	na		42	na	0	0
2002	na	na	na	na		342	50,681	68	11,350
2003	na	na	na	na		16		67	21,713
2004	na	na	11	2,996		20	2,335	281	50,934
2005	na	na	9	3,030		120	28,260	147	25,092
2006	0	0	na	na		327	92,804	48	22,210
2007	0	0	4	2,606		261	76,570	116	51,106
2008	0	0	14	3,306		108	33,425	234	54,645
2009	0	0	0	0					
2010	0	0	0	0					
2011	14	5,819	5	1,193					
2012	21	15,457	4	1,752					
2013	17	8,142	na	na					
2014	0	0	na	na					
2015	0	0	14	3,055					
2016	0	0	13	3,058					
2017	7**	8,437	5	790					
<i>Total</i>	<i>2006-2017: 59</i>		<i>2004-2017: 92</i>			<i>2002-2008: 986</i>		<i>2002-2008: 951</i>	

In the Ambler District, the EARLY stages of exploration have shown there are rich grades of ore. Trilogy is in the MIDDLE stage of exploration, the point where a company needs to determine whether the ore body has the grade, shape, continuity, and depth to the extent they can state they have high confidence in the deposit. At the LATE stage, they will need to consider more than the ore body. This is where the company needs to develop a Feasibility Study, a detailed mine plan, and weight the costs with the potential income. One of the costs to be considered will be the cost of getting the produced concentrate to a shipping port. The Ambler Road would be one leg of this transport.

It is much too early for the State to consider funding infrastructure. This should be delayed until, at a minimum, there is high confidence (“Measured Resources”) in at least a few ore deposits, and preferably

delayed until Feasibility Studies are released. Because the cost of moving the product to market will need to be figured into the viability of mining, the State should be very clear on the economics – if the State did *not* pay for an access road, would any ore bodies have “Probable Reserves”? What is the full cost of transportation from mine to market? These are questions that will need to be addressed in a Feasibility Study.

Information regarding additional prospects in the Ambler District

AIDEA has a conceptual plan of four mines opening simultaneously: Arctic, Bornite, Sun, and Smucker.

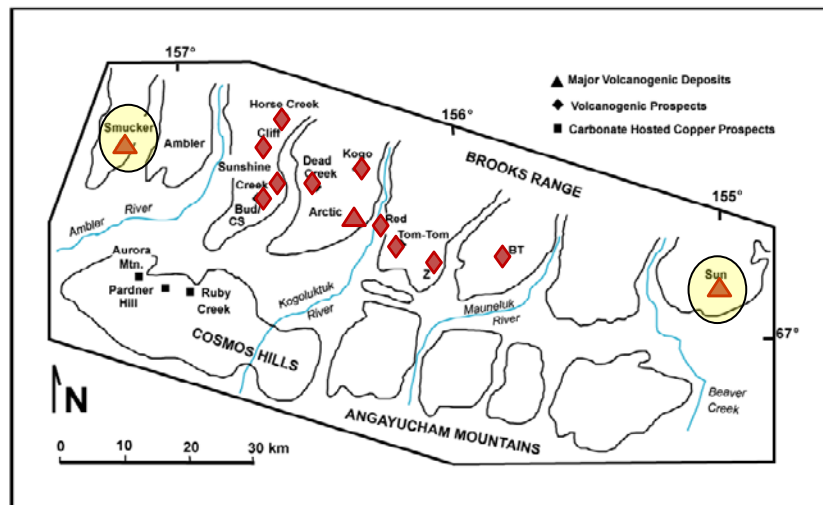
“Access to the region could spur the development of existing mining projects such as the Arctic, Bornite, Sun, and Smucker Projects, each of which has large estimated mineral reserves..... There are four major mineral deposits within the District in different stages of exploration (the Arctic, Bornite, Sun, and Smucker deposits).”³

However, there has been no interest in exploring Sun or Smucker. Prior owners of Sun included Anaconda, Noranda, Cominco, and Bear Creek (Rio Tinto). Andover Mining, 100% owner of the Sun deposit until recently, announced “The Sun property is an advanced stage Alaska project”,⁴ but with 96 holes completed through 2013, only 68M lbs of copper and 196M lbs of zinc were reported as Indicated Resources. By 2014 Andover was bankrupt. As of November 2017, Enirgi Group owned the claims, and did not appear to be actively exploring.⁵

Teck owns the Smucker deposit, but is not exploring. Although located not far from Red Dog, Smucker is such a minor asset that Teck does not mention it in any of its annual reports or on its website. As with the Sun deposit, only historical “relevant but not necessarily reliable” resource information is reported.⁶

Figure 2. Ambler District deposits.

Sun and Smucker are highlighted in yellow. Deposits that are likely sulfidic are noted in red triangles or diamonds. From NovaCopper, SEC Form 10K for the fiscal year ending November 30, 2012, Figure 2.



³ Cardno 2015

⁴ <https://www.google.com/finance?cid=6848415>

⁵ NovaCopper 2016

⁶ NovaCopper 2013

Information regarding Geology as it informs risk and cost

The deposits along the southern flank of the Brooks Range are “Volcanic Massive Sulfide” type deposits. This means the ore (economic minerals) and likely the host rock (waste) will be dominated by sulfides. The Arctic deposit mineralization is mineralization is predominately coarse-grained sulfides consisting mainly of chalcopyrite (copper-iron sulfide), sphalerite (zinc-iron sulfide), galena (lead sulfide), tetrahedrite-tennantite (copper-iron-antimony sulfide) and copper-iron-zinc-arsenic sulfide), arsenopyrite (arsenic-iron sulfide), pyrite and pyrrhotite (iron sulfides).

As material is blasted, moved, crushed, and disposed of, sulfides weather and produce sulfuric acid, which in turn liberates the metals in the surrounding rock matrix. This process is referred to as “acid rock drainage” or ARD. Handling ARD is often the single most costly aspect of mining sulfide deposits. Costs are associated along the entire life of the mine. In the early stages, consultants must be hired to determine how aggressive the ARD will be – that is, will material go acid in one year, 5 years, 40 years – and the concentration of metals that are likely to be liberated. This informs mine design and closure.

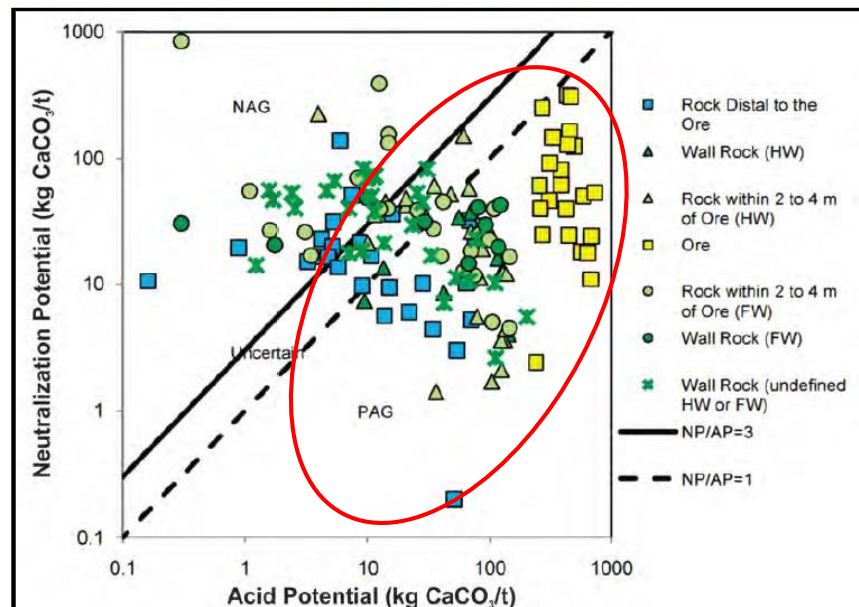
Trilogy has had some geochemistry conducted, and work appears to be ongoing. Early work shows that all of the ore, unsurprisingly, is acid generating; most of the host rock that needs to be moved to reach ore is also acid generating. This has cost implications for mine design, water treatment, and mine closure.

In particular, current early estimates of the cost of closure may be underestimated. The Arctic Pre-Feasibility Study estimates closure at \$65.3 million.⁷ This may be greatly underestimated. Red Dog initially had a bond for \$21 million in 2006, which was increased to over \$300 million, due in part to ARD conditions.⁸

Figure 3. Geochemistry of rock samples.

The figure shows rock samples and where they fall in the ratio of potential to produce acid (PAG rock) or the potential to neutralize acid (NAG rock). From the NovaCopper 2013 Preliminary Economic Assessment.

Figure 9.6 PAG versus NAG by Rock Type at the Arctic Deposit



⁷ Trilogy 2018

⁸ DNR 2010

REFERENCES

Cardno. 2015. Ambler Mining Region Economic Impact Analysis. Prepared for AIDEA, February 2.

DNR. 2010. Mining reclamation bond for Red Dog

NovaCopper. 2013. Arctic PEA Section 23.2 and others

NovaCopper. 2016. NI 43-101 Technical Report on the Bornite project

Placer Dome 2000 Annual Report

Rebagliati, CM and JG Payne. 2004 Summary report on the Pebble porphyry gold-copper project, for Northern Dynasty Minerals

Rebagliati et al 2008. Technical Report on the 2007 program and update on metallurgy and resources on the Pebble copper-gold-molybdenum project, for Northern Dynasty Minerals

SRK. 2006. Preliminary assessment, Donlin Creek gold project. Table 1 and Section 4.12

Trilogy. 2018. February 20 news release

Table 1 and 2

NovaCopper. 2007 Annual report , February 2008 NI 43-101 Technical report table 15.1.8.1, Section 4.2

NovaCopper. May 2011 NI 43-101 Technical report, Section 9.2 and Table 15.13.1

NovaCopper. February 2013 NI 43-101 Technical report table 14.13

NovaCopper. September 2013 PEA table 25.1 and 2013 Annual 10K reporting form table 4

NovaCopper. 2013 Annual 10K form table 6

NovaCopper. April 2014 NI 43-101 Technical report table 14.9

NovaCopper. 2015 Annual 10K Table 3

NovaCopper. May 2016 NI 43-101 Technical report Table 10-1, 2016 10 27 Trilogy drill results

SRK. 2012. NI 43-101 Preliminary economic assessment, Ambler project, Kobuk AK. Report to NovaCopper, Tables 2 and 12.11.1

Trilogy. October 2017 Amended NI 43-101 Technical report

Trilogy. November 2017 NI 43-101 Technical Report

Trilogy. March 2018 corporate presentation

Table 3

As for Table 1, and SRK 2006, Rebagliati 2008, and Rebagliati and Payne 2004.