MOREV Tool

Mineral Occurrence Revenue Estimation & Visualization Tool

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www.mtri.org
www.mtri.org/mineraloccurrence.html

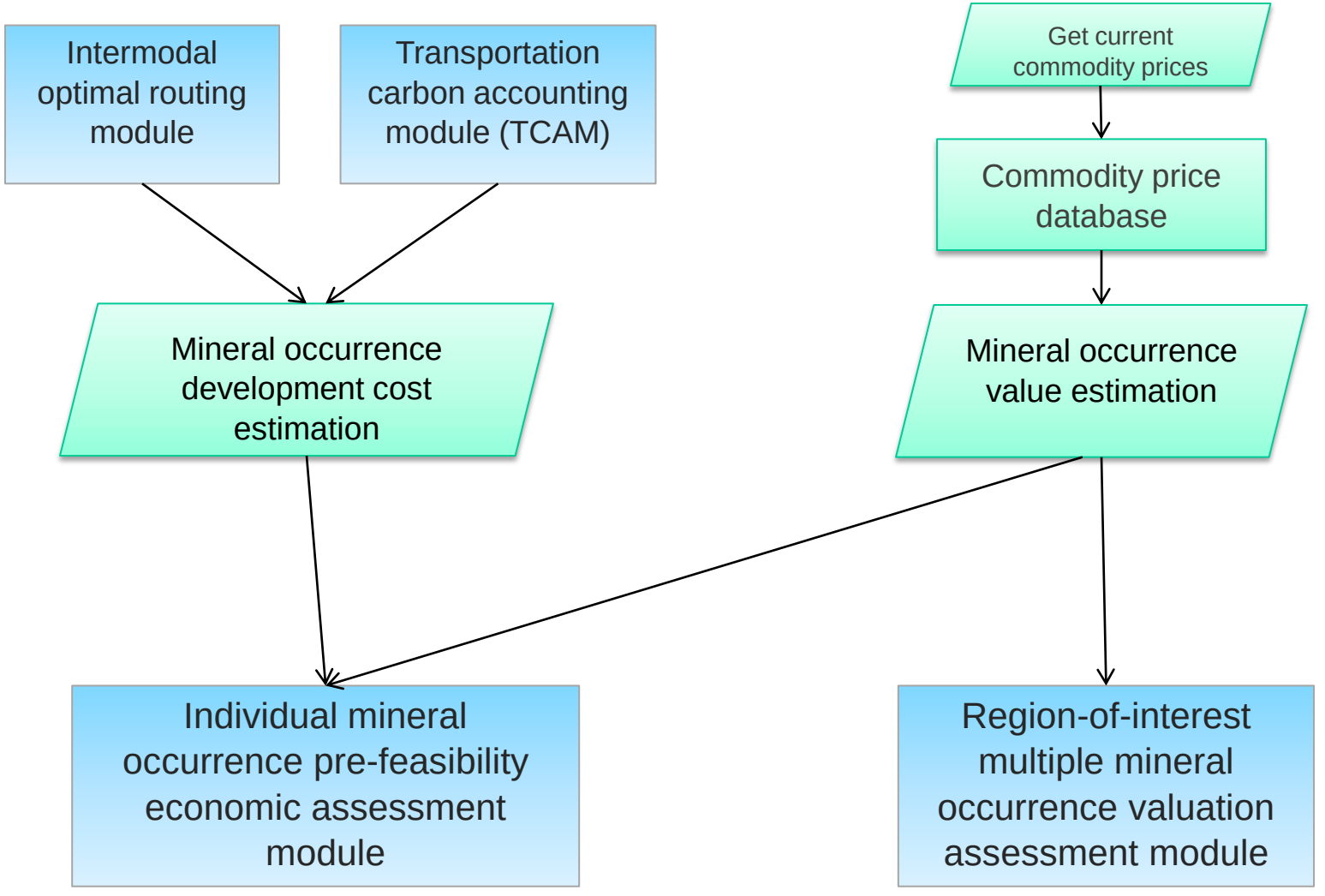
What is the MOREV Tool?

- An ArcMap-based suite of tools developed in order to effectively assess and communicate the value of mineral occurrences within regions of interest in Alaska, Yukon Territory, and British Columbia
- Primary purpose: spatialized mineral occurrence valuation
- Auxiliary functions:
  - Pre-feasibility economic assessments of individual mineral occurrences
  - Ability to modify commodity prices, or use the most recently available commodity prices
  - Intermodal (road, rail, water) transportation network for optimal routing
    - e.g., how much does it cost to ship the ore to a processing facility in China?
  - Carbon emissions accounting from transportation

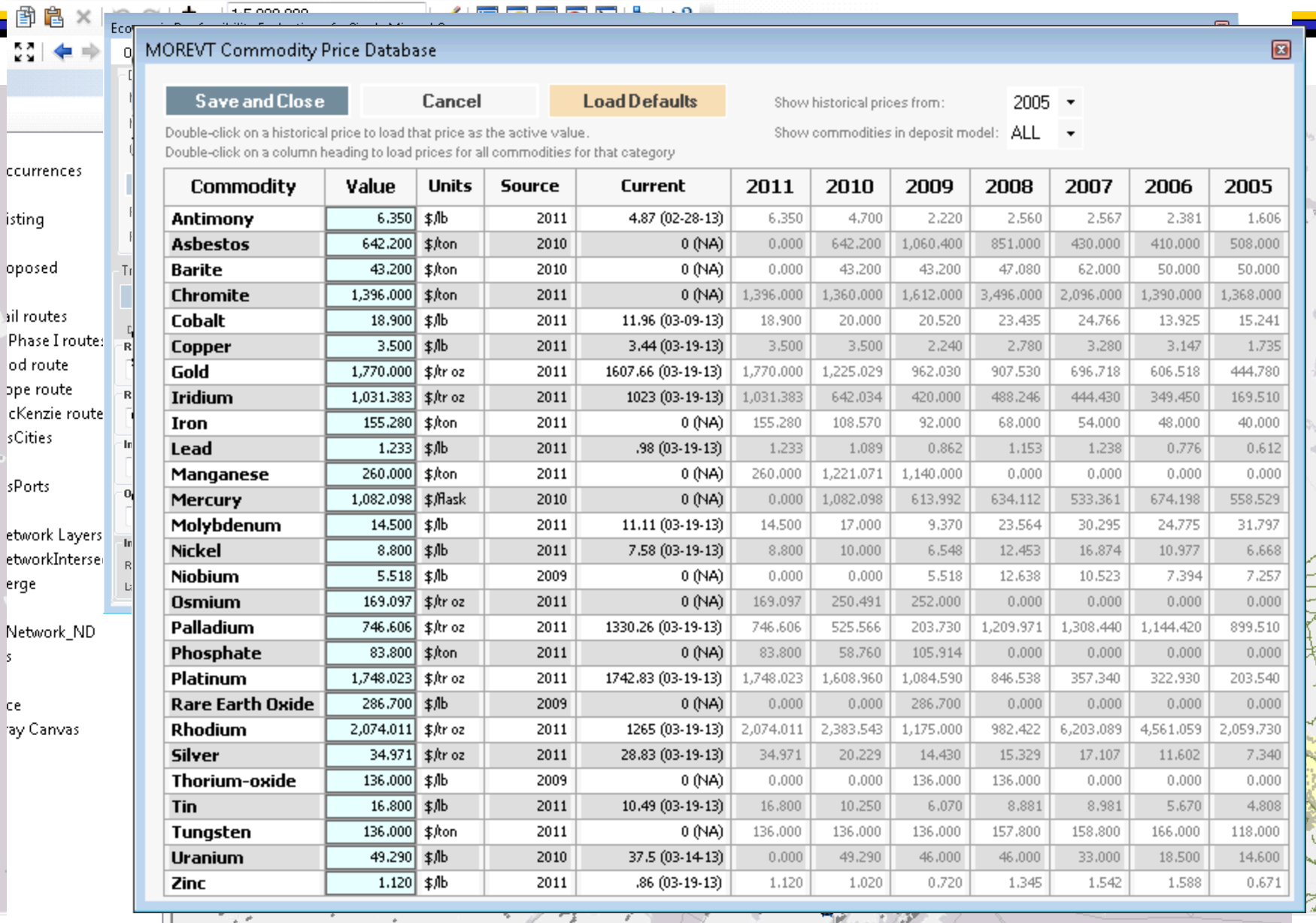
Potential Users

- Small to midsized exploration interests in pre-feasibility stages of project planning for new mining projects
- Transportation & infrastructure planners
  - State & local government
- Potential for helping in permitting process
  - Example: Preparation of NI 43-101 mineral project disclosures in Canada
- Government agencies & resource database maintainers
- Investment community & lenders
- Researchers (geological, transportation, economic, etc.)

Tool Components

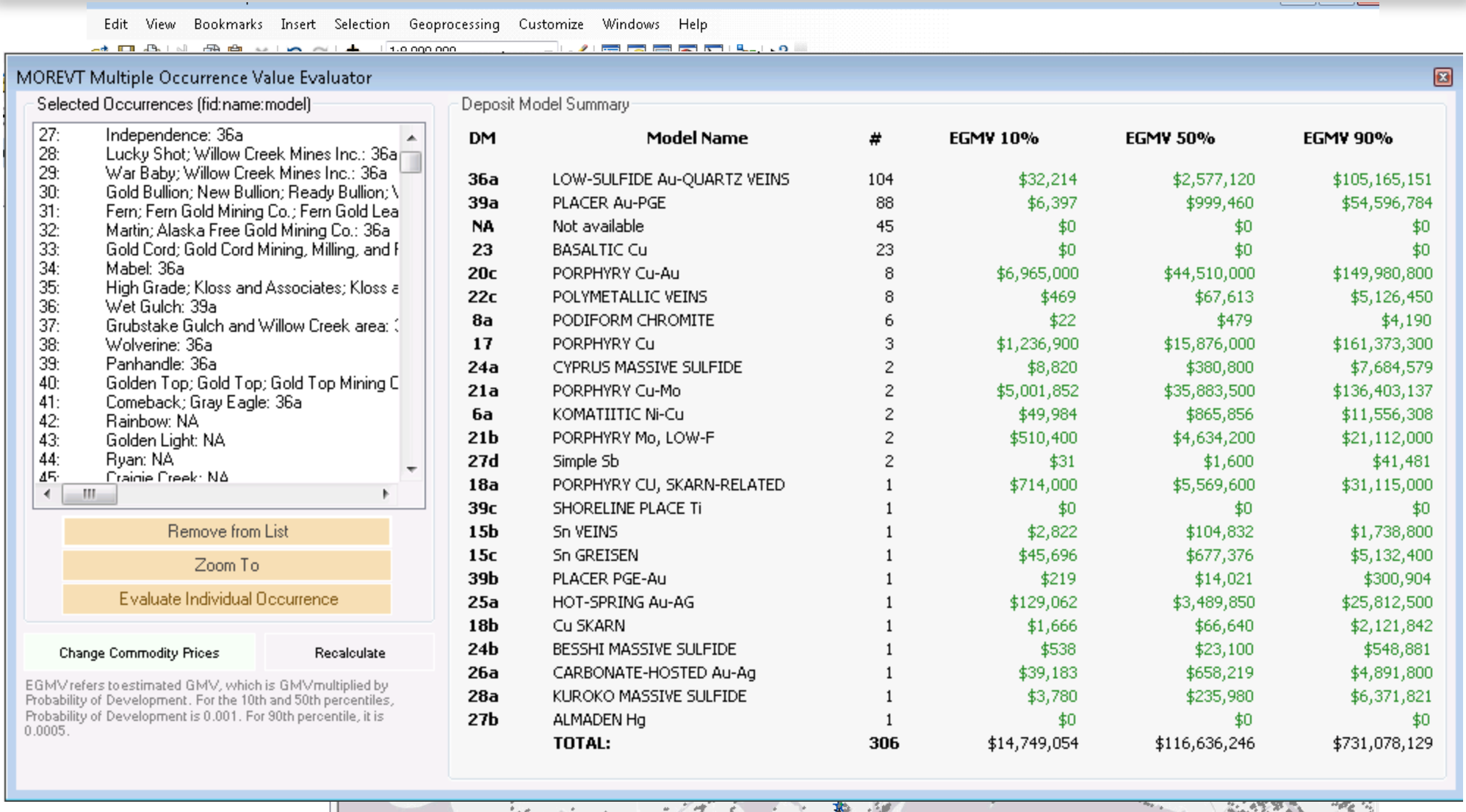


Example Single Mineral Occurrence Selection



Commodity	Value	Units	Source	Current	2011	2010	2009	2008	2007	2006	2005
Antimony	6.350	$/lb	2011	4.87 (02-28-13)	6.350	4.700	2.220	2.560	2.567	2.381	1.606
Asbestos	642.200	$/ton	2010	0 (NA)	0.000	642.200	1,060.400	851.000	430.000	410.000	508.000
Barite	43.200	$/ton	2010	0 (NA)	0.000	43.200	43.200	47.080	62.000	50.000	50.000
Chromite	1,396.000	$/ton	2011	0 (NA)	1,396.000	1,360.000	1,612.000	3,496.000	2,096.000	1,390.000	1,368.000
Cobalt	18.900	$/lb	2011	11.96 (03-09-13)	18.900	20.000	20.520	23.435	24.766	13.925	15.241
Copper	3.500	$/lb	2011	3.44 (03-19-13)	3.500	3.500	2.240	2.780	3.280	3.147	1.735
Gold	1,770.000	$/tr oz	2011	1607.66 (03-19-13)	1,770.000	1,225.029	962.030	907.530	696.718	606.518	444.780
Iridium	1,031.383	$/tr oz	2011	1023 (03-19-13)	1,031.383	642.034	420.000	488.246	444.430	349.450	169.510
Iron	155.280	$/ton	2011	0 (NA)	155.280	108.570	92.000	68.000	54.000	48.000	40.000
Lead	1.233	$/lb	2011	.98 (03-19-13)	1.233	1.089	0.862	1.153	1.238	0.776	0.612
Manganese	260.000	$/ton	2011	0 (NA)	260.000	1,221.071	1,140.000	0.000	0.000	0.000	0.000
Mercury	1,082.098	$/flask	2010	0 (NA)	0.000	1,082.098	613.992	634.112	533.361	674.198	558.529
Molybdenum	14.500	$/lb	2011	11.11 (03-19-13)	14.500	17.000	9.370	23.564	30.295	24.775	31.797
Nickel	8.800	$/lb	2011	7.58 (03-19-13)	8.800	10.000	6.548	12.453	16.874	10.977	6.668
Niobium	5.518	$/lb	2009	0 (NA)	0.000	0.000	5.518	12.638	10.523	7.394	7.257
Osmium	169.097	$/tr oz	2011	0 (NA)	169.097	250.491	252.000	0.000	0.000	0.000	0.000
Palladium	746.606	$/tr oz	2011	1330.26 (03-19-13)	746.606	525.566	203.730	1,209.971	1,308.440	1,144.420	899.510
Phosphate	83.800	$/ton	2011	0 (NA)	83.800	58.760	105.914	0.000	0.000	0.000	0.000
Platinum	1,748.023	$/tr oz	2011	1742.83 (03-19-13)	1,748.023	1,608.960	1,084.590	846.538	357.340	322.930	203.540
Rare Earth Oxide	286.700	$/lb	2009	0 (NA)	0.000	0.000	286.700	0.000	0.000	0.000	0.000
Rhodium	2,074.011	$/tr oz	2011	1265 (03-19-13)	2,074.011	2,383.543	1,175.000	982.422	6,203.089	4,561.059	2,059.730
Silver	34.971	$/tr oz	2011	28.83 (03-19-13)	34.971	20.229	14.430	15.329	17.107	11.602	7.340
Thorium-oxide	136.000	$/lb	2009	0 (NA)	0.000	0.000	136.000	136.000	0.000	0.000	0.000
Tin	16.800	$/lb	2011	10.49 (03-19-13)	16.800	10.250	6.070	8.881	8.981	5.670	4.808
Tungsten	136.000	$/ton	2011	0 (NA)	136.000	136.000	136.000	157.800	158.800	166.000	118.000
Uranium	49.290	$/lb	2010	37.5 (03-14-13)	0.000	49.290	46.000	46.000	33.000	18.500	14.600
Zinc	1.120	$/lb	2011	.86 (03-19-13)	1.120	1.020	0.720	1.345	1.542	1.588	0.671

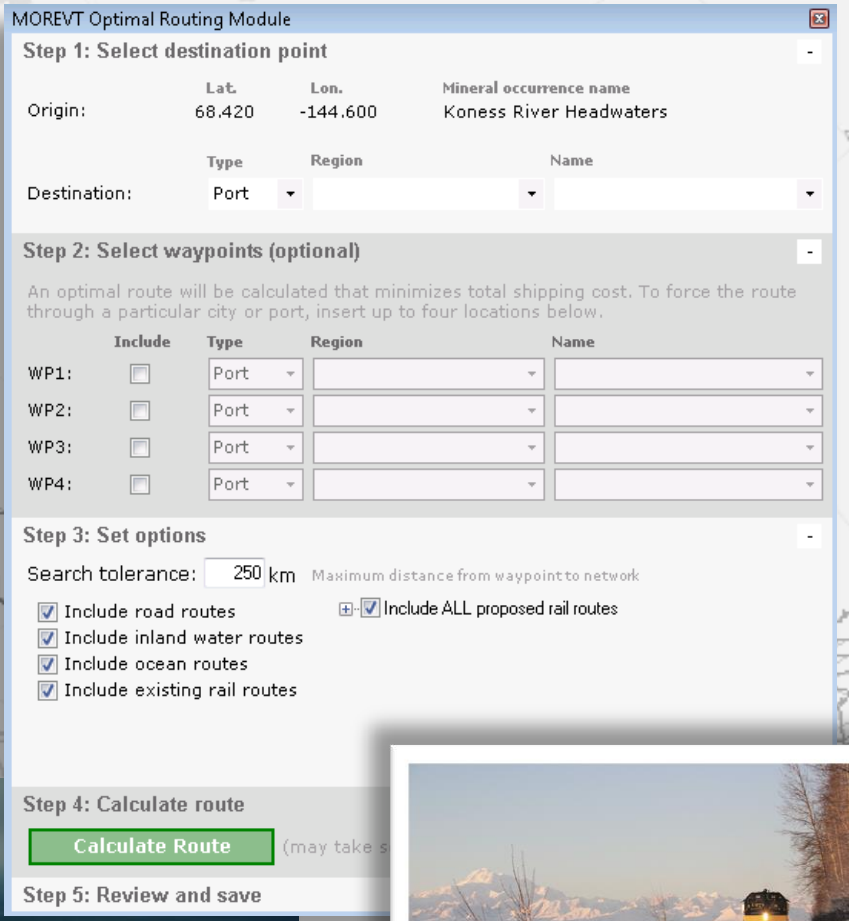
Example Multiple Mineral Occurrence Selection



DM	Model Name	#	EGMV 10%	EGMV 50%	EGMV 90%
36a	LOW-SULFIDE Au-QUARTZ VEINS	104	$32,214	$2,577,120	$105,165,151
39a	PLACER Au-PGE	88	$6,397	$999,460	$54,596,784
NA	Not available	45	$0	$0	$0
23	BASALTIC Cu	23	$0	$0	$0
20c	PORPHYRY Cu-Au	8	$6,965,000	$44,510,000	$149,980,800
22c	POLYMETALLIC VEINS	8	$469	$67,613	$5,126,450
8a	PODIFORM CHROMITE	6	$22	$479	$4,190
17	PORPHYRY Cu	3	$1,236,900	$15,876,000	$161,373,300
24a	CYPRUS MASSIVE SULFIDE	2	$8,820	$380,800	$7,684,579
21a	PORPHYRY Cu-Mo	2	$5,001,852	$35,883,500	$136,403,137
6a	KOMATIITIC Ni-Cu	2	$49,984	$865,856	$11,556,308
21b	PORPHYRY Mo, LOW-F	2	$510,400	$4,634,200	$21,112,000
27d	Simple Sb	2	$31	$1,600	$41,481
18a	PORPHYRY CU, SKARN-RELATED	1	$714,000	$5,569,600	$31,115,000
39c	SHORELINE PLACE Ti	1	$0	$0	$0
15b	Sn VEINS	1	$2,822	$104,832	$1,738,800
15c	Sn GREISEN	1	$45,696	$677,376	$5,132,400
39b	PLACER PGE-Au	1	$219	$14,021	$300,904
25a	HOT-SPRING Au-AG	1	$129,062	$3,489,850	$25,812,500
18b	Cu SKARN	1	$1,666	$66,640	$2,121,842
24b	BESSHI MASSIVE SULFIDE	1	$538	$23,100	$548,881
26a	CARBONATE-HOSTED Au-Ag	1	$39,183	$658,219	$4,891,800
28a	KUROKO MASSIVE SULFIDE	1	$3,780	$235,980	$6,371,821
27b	ALMADEN Hg	1	$0	$0	$0
	TOTAL:	**306**	$14,749,054	$116,636,246	$731,078,129

Intermodal Optimal Routing Module

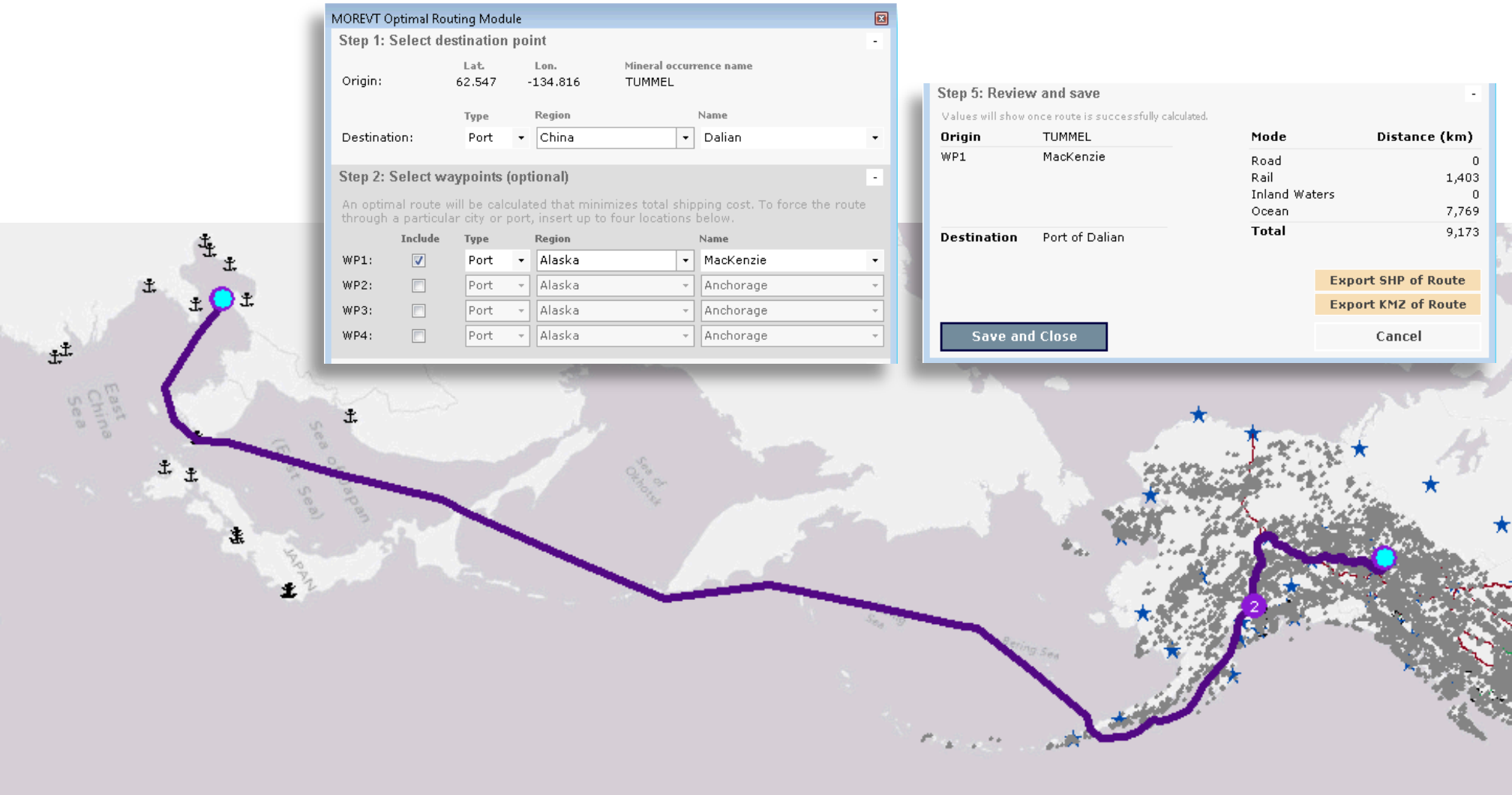
- A route is calculated from mineral occurrence **origin** to **destination** point (port, cities, or facilities in U.S., Canada or overseas)
- Most cost efficient route is automatically chosen, but user can force route through waypoints
- Like Google/Yahoo Maps! Except intermodal.



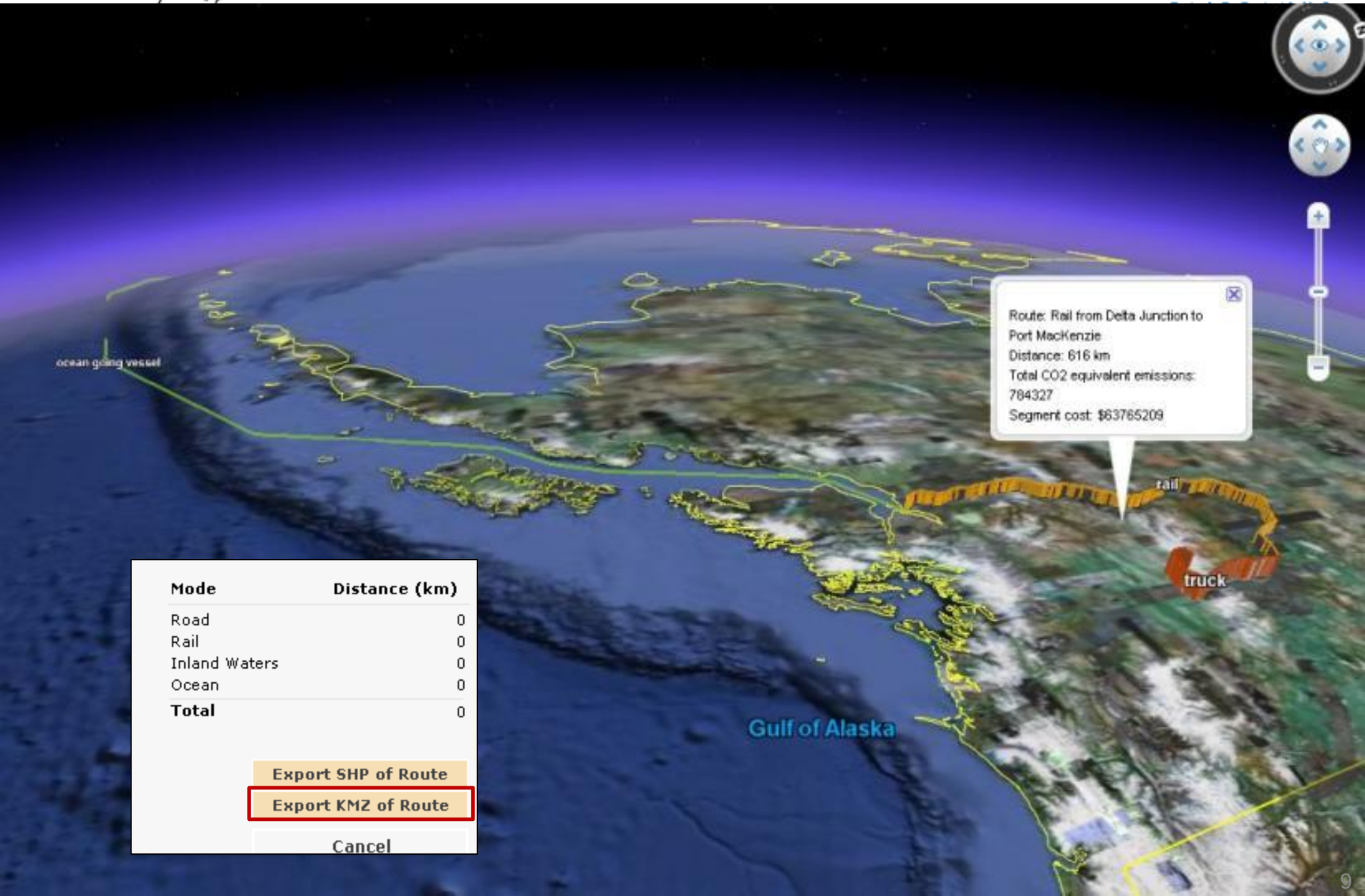
Intermodal Optimal Routing Module

Users can choose origins & destinations

- After a route is successfully calculated, you can review, export the route to SHP/KML, and save the values, which are loaded directly into the costing calculations



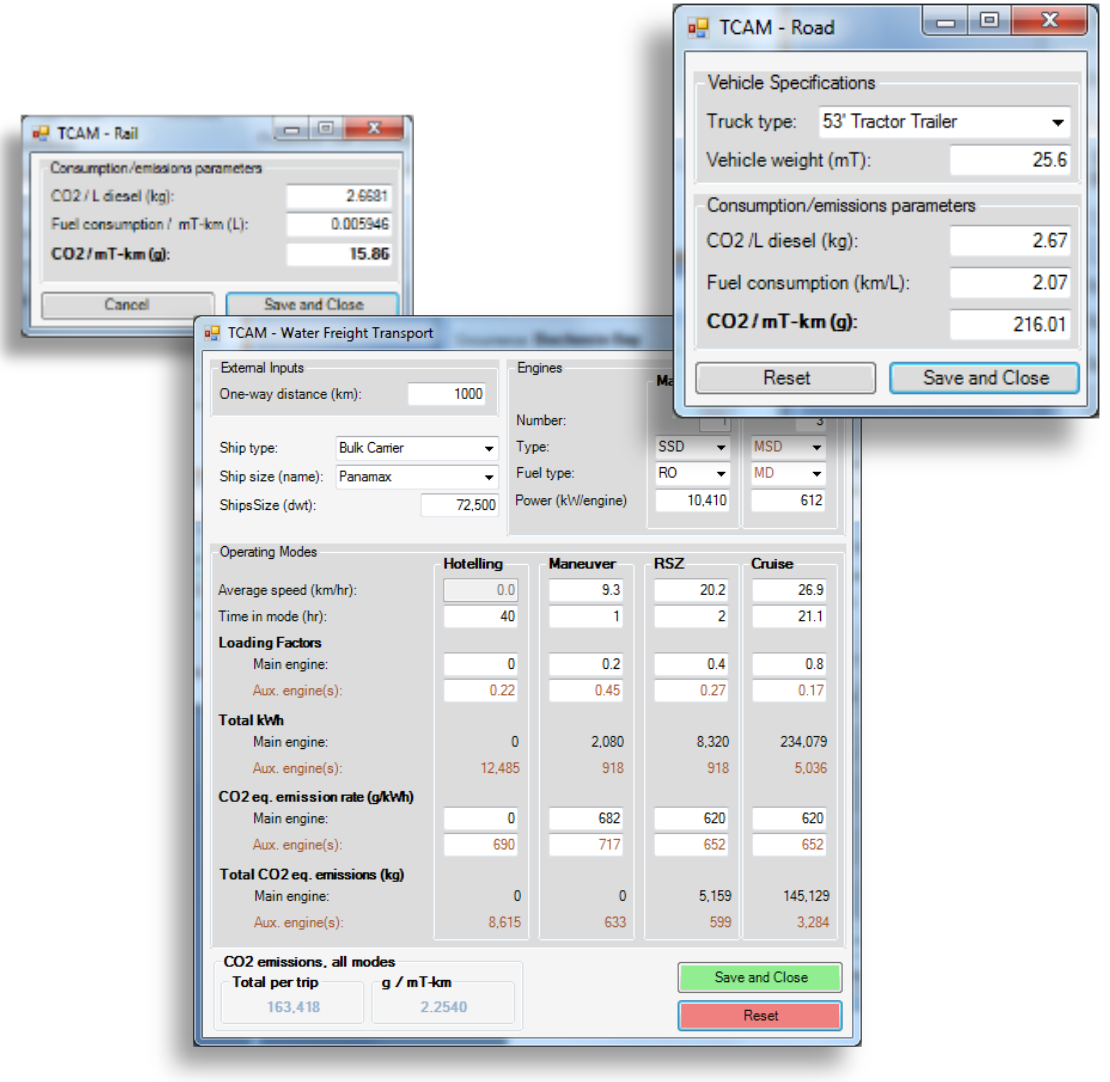
Route KML in Google Earth



Carbon Accounting

Transportation Carbon Accounting Module (TCAM)

- **Rail**, **truck**, **barge**, and **OGV** (ocean going vessel) emissions models are incorporated
- Mode-specific calculator forms show model assumptions and allow user-modification of default parameters
- Uses **CO_2 equivalent values** (includes:CO_2, CH_4, and N_2O)
- Sources for fuel consumption/emissions model data:
  - **Rail**: Association of American Railroads, US EPA
  - **Truck**: USDOT Federal Highway Administration, Vehicle Inventory and Use Survey (VIUS) 2002, US EPA
  - **Water**: MAN Diesel, European Environment Agency, US EPA, ICF International, Lloyd's Register



Example MOREV Tool Analyses:
Alaska Pipeline Project

- We used the MOREV Tool to evaluate potential revenue from mineral occurrences within corridors of two separate pipeline routes

Alaska Pipeline Project - Updated 11/2/2010 with Development Probability

Model Code	Name	Metals	Amt	GMV (10th Perc.)	GMV (50th Perc.)	GMV (90th Perc.)
10	Carbonatite	Niobium - Rare Earth	1	$771,795,431	$9,329,300,739	$38,420,308,164
26a	Carbonate-Hosted Au-Ag	Au-Ag	1	$277	$4,707	$33,641
27b	Almaden Hg	Hg	1	$0	$0	$0
30a	Sandstone-Hosted Pb-Zn	Pb-Zn-Ag	1	$9,896	$304,823	$4,793,022
31b	Bedded Barite	Barite	1	$1,489	$30,713	$260,597
38a	Lateritic Ni	Ni-Co	1	$1,247,069	$9,779,654	$38,216,657
39b	Placer PGE-Au	Pt-Au-Os-Ir-Pl	1	$157	$11,918	$253,611
9	Alaskan PGE and Epiterthermal Veins	Pt	1	$0	$0	$0
14b	Sn Skarn	Sn	2	$45,007	$630,525	$4,768,965
15b	Sn Veins	Sn	2	$1,818	$67,510	$1,119,755
25g	Epithermal Mn	Mn	2	$2,523	$39,424	$275,968
39c	Shoreline Placer Ti	Zr-Ti	2	$149,486	$7,742,151	$152,147,019
6a	Komatitic Ni-Cu	Ni-Au-Cu	2	$31,998	$540,902	$6,552,870
15c	Sn Greisen	Sn	3	$44,141	$654,326	$4,957,754
20b	Sn-polymetallic veins	Au-Ag-Pb-Zn	3	$0	$0	$0
32a	Mississippi Valley Zn-Pb	Pb-Zn	3	$0	$0	$0
24c	Volcanogenic Mn	Mn	4	$7,065	$207,528	$2,343,891
31a	Sedimentary Exhalative Zn-Pb	Zn-Pb	4	$469,315	$9,963,579	$106,186,580
18a	Porphyry Cu Skarn	Cu-Ag-Au-Mo	5	$3,135,635	$23,837,669	$90,867,849
8d	Serpentine-Hosted Asbestos	Asbestos	6	$61,078	$588,154	$2,950,605
18d	Fe Skarn	Fe	7	$654,326	$19,828,066	$277,592,918
19a	Polymetallic Replacement	Pb-Zn-Cu-Ag-Au	7	$57,062	$1,872,126	$30,815,076
18c	Zn-Pb Skarn	Zn-Pb-Cu	8	$72,529	$1,594,558	$17,322,805
21a	Porphyry Cu-Mo	Cu-Mo-Au-Ag	8	$15,788,676	$110,237,308	$397,001,891
21b	Porphyry Mo, Low F	Mo	9	$1,789,382	$16,246,773	$74,015,336
25a	Hot Spring Au-Ag	Au-Ag	12	$0	$0	$0
17	Porphyry Cu	Cu-Ag-Au-Mo	19	$6,709,091	$86,823,819	$632,182,850
34c	Phosphates	P_2O_5-P	19	$0	$0	$0
20c	Porphyry Cu-Au	Cu-Au-Ag-Mo	23	$11,927,285	$67,332,511	$202,579,108
14a	W Skarn	W	24	$9,738	$422,162	$8,821,286
24b	Besshi Massive Sulphide	Cu-Ag-Au-Pb-Zn	28	$13,550	$574,074	$11,034,567
8a	Pociform Chromite	Cr	33	$82,492,478	$10,453,592,312	$59,085,521,764
18b	Cu Skarn	Cu-Ag-Au	34	$35,981	$1,442,311	$27,864,929
27d	Simple Sb Deposits	Sb-Ag-Au	34	$138	$7,222	$186,206
5b	Noril'sk Cu-Ni-PGE	Au-Pd-Pt	50	$0	$0	$0
24a	Cyprus Massive Sulphide	Cu-Ag-Au-Pb-Zn	52	$206,510	$8,853,963	$115,958,480
28a	Kuroko Massive Sulphide	Cu-Pb-Zn-Au-Ag	79	$344,782	$14,664,440	$285,809,883
23	Basaltic Copper	Au-Ag-Cu-Ni-Zn-Co	88	$0	$0	$0
22c	Polymetallic Veins	Ag-Au-Pb-Zn-Cu	115	$1,596	$152,342	$7,481,083
36a	Low Sulfide Au-Quartz Veins	Au-Ag	367	$591	$47,265	$6,399,194
	No Description		405	$0	$0	$0
39a	Placer Au-PGE	Au-Ag	520	$3,309	$39,426	$2,150,505
	TOTALS		1987	$897,109,410	$20,167,434,999	$100,018,774,830

Example MOREV Tool Analyses:
Klondike Highway Freight Forecasts

- We provided estimated freight volumes from mineral occurrence development to the Alaska Department of Transportation (AKDOT) for their 20 year freight forecasts.
- These forecasts are used to inform the toll rates required to pay for highway maintenance

Freight Volume Projections from MOREV

BC Highway 37

Corridor length (km) 461

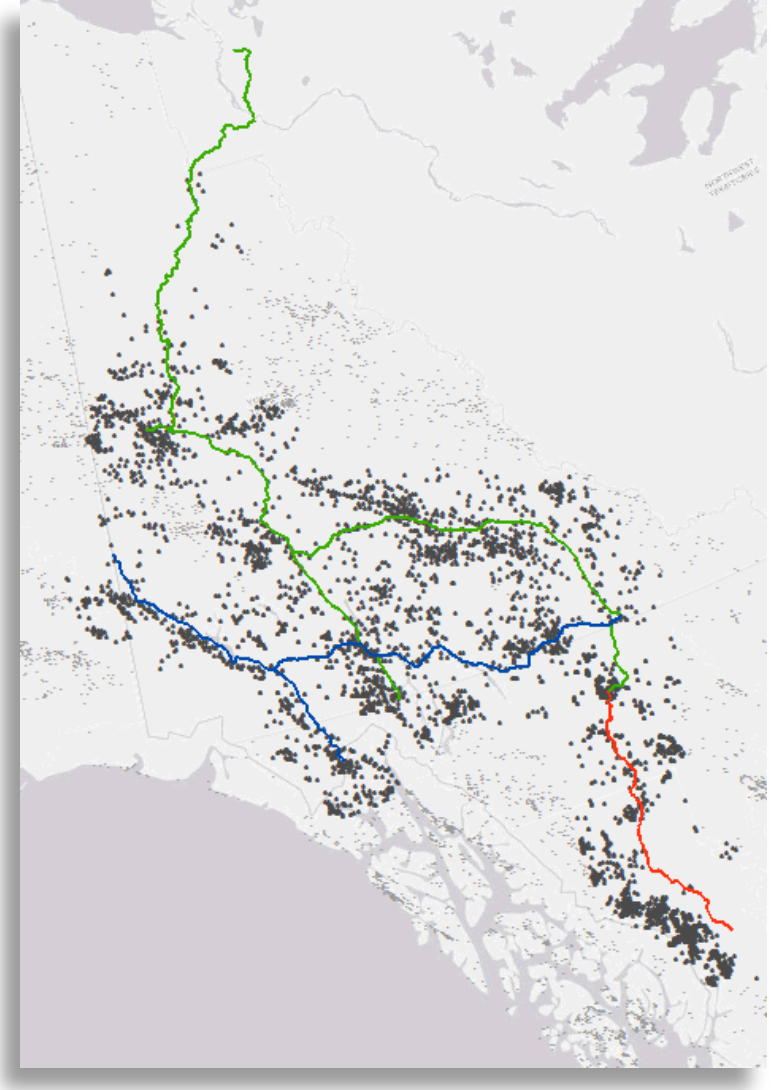
Mineral Occurrence Summary

w/in corridor 1357
w/ assigned DMs 730
w/ quantified DMs 711

unquantified DMs in gray italics

Freight Volume by Mineral Occurrence (mT/day)

		10th Percentile				50th Percentile				90th Percentile			
		per occurrence		all occurrences		per occurrence		all occurrences		per occurrence		all occurrences	
Deposit model	**#**	**Above**	**Under**	**Above**	**Under**	**Above**	**Under**	**Above**	**Under**	**Above**	**Under**	**Above**	**Under**
NA	*627*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
22c	544	0.2	0.3	109	163	9	8	4733	4134	272	180	147968	98083
17	67	38.6	17.3	2586	1159	246	93	16469	6211	1683	532	112761	35637
36a	31	0	0	0	0	0	0	0	0	0	0	0	0
21b	23	3.6	1.6	83	37	17	7	400	156	85	28	1946	651
39a	22	0	0	0	0	0	0	0	0	0	0	0	0
18a	21	65.7	29.3	1380	615	310	123	6514	2579	1497	526	31435	11048
22a	*19*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
23	2	143	100.6	286	201	1214	644	2428	1287	2932	1383	5864	2765
18b	1	1.4	1.1	1	1	22	13	22	13	311	149	311	149
TOTAL	**1357**			**4,445**	**2,177**			**30,565**	**14,381**			**300,285**	**148,333**
Normalized by PoD (mT/day)				**4.4**	**2.2**			**30.6**	**14.4**			**300.3**	**148.3**
Mean per quantified DM (mT/day)				0.0065	0.0032			0.0430	0.0202			0.4358	0.2153
Annual projected (mT/yr)				**1,600**	**784**			**11,004**	**5,177**			**108,103**	**53,400**
Annual projected (mT/km/yr)				3.5	1.7			23.9	11.2			234.5	115.8



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