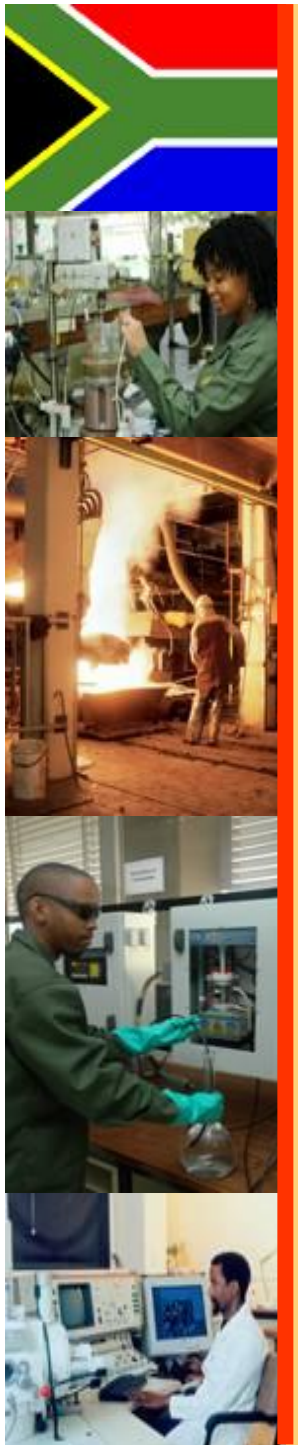

Council for Mineral Technology

A global leader in mineral and metallurgical innovation

Presentation to

MINTEK 75 – Conference

"Practical Aspects of Cyanide Management"

4.06.2009

Peter Lotz
Head: Gold Process & Environment

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- Glance back over our shoulders
- Incident history; are we improving?
- A crash course on cyanide for non-gold miners…
- How do we go about risk assessing cyanide use?
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- The ICMI code (don't we all love audits?)
- Taking bets on the future?

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Glance back over our shoulders

Not too many years ago, when visiting gold plants….

- **It was not uncommon that a plant was unsure whether the data for residue was actually expressed as cyanide or NaCN (f=2)**
- **The only known cyanide species was the "titratable" one**
- **A water balance was said to be established when a sheet of paper stated that ~60% of the discharge water returns to plant**
- **Plant automation was often in its infancy**
- **"Plant Maintenance" meant that you don't fix what isn't broken**
- **Cyanide destruction meant to have a bag of $FeSO_4$ at the ready**
- **Sulfate loads, arsenic levels did not have to be taken too seriously**

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Incident history; are we improving?

- Since Baia Mare no major tailings incident,
- Still on-going minor transport and spillage incidents
- Result of the ICMI code launch?
- Even code signatories still have the potential to proudly do the wrong thing (adding peroxide to rivers and streams; Ghana-Bogoso)

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Risk Potentials….physical types

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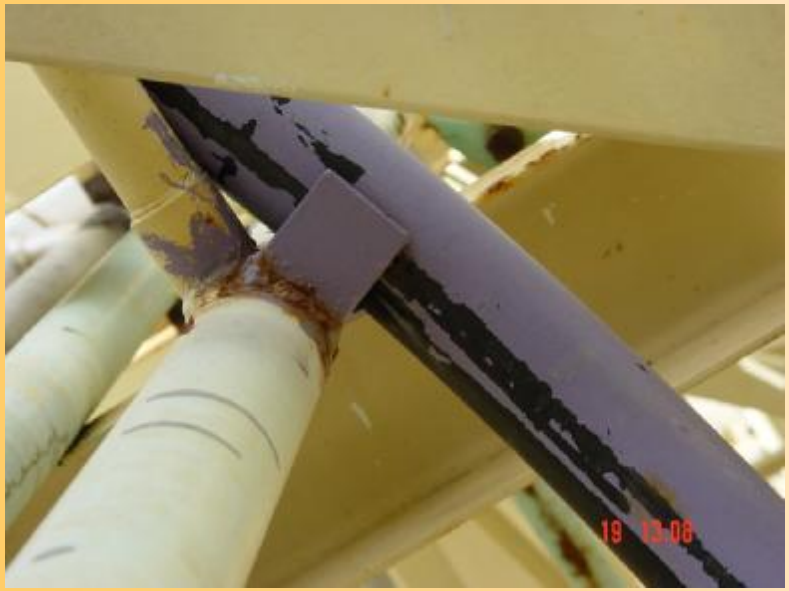
Risk Potentials… physical types



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How do we go about risk assessing cyanide use?

1. Assess all the **prevailing CN species** throughout the process and discharge circuits (including side streams like elution barren)
2. Establish the **stability of the plant**; high/low conditions and their frequency
3. Establish a proper **probabilistic water balance** that deserves that name (including **all** managed batch streams, **most current** changes in local rain-fall (snow?) patterns, up-dated run-on/run-off areas, pump capacities, discharge limitations etc)
4. Identify the **hot-spots** through solution and gas phase composition modeling and experimental verification of “what-if” scenarios (combine 1-3 for this); **use auditing to cross-check**
5. Take a forward look on **future mineralogy** **and resulting cyanide speciation**
6. **Stack the identified** **risks against all issues**, for example regulatory compliance (personal liabilities?), ICMI code compliance, public discord, insurance cost, capital sourcing limitations etc

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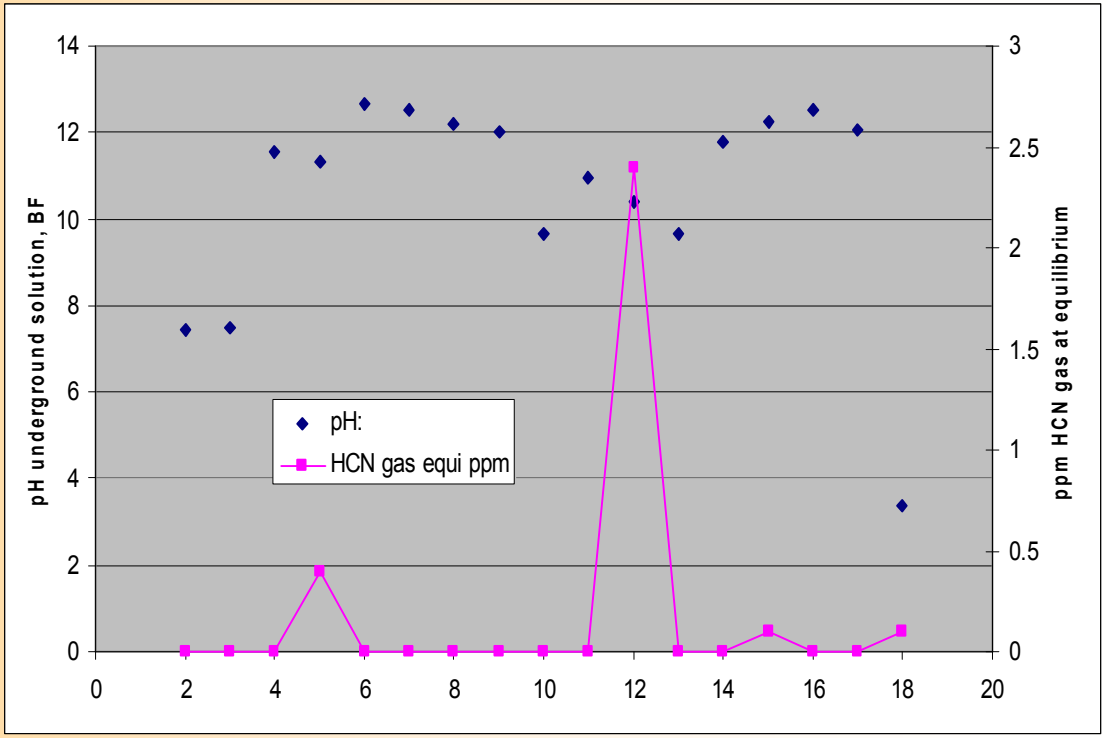
Example: Risk assessment HCN from backfill



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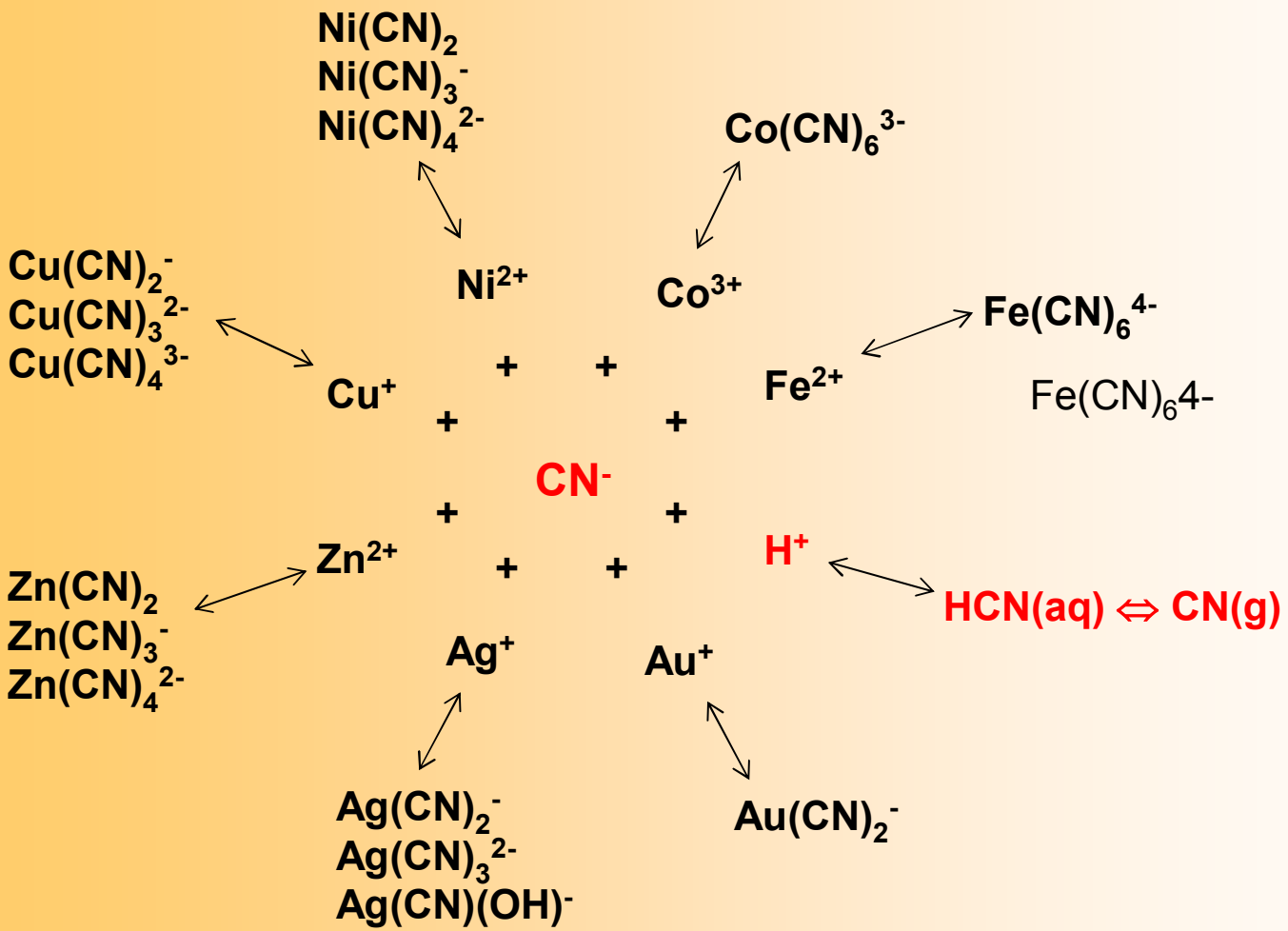
A crash course on cyanide for non-gold miners…

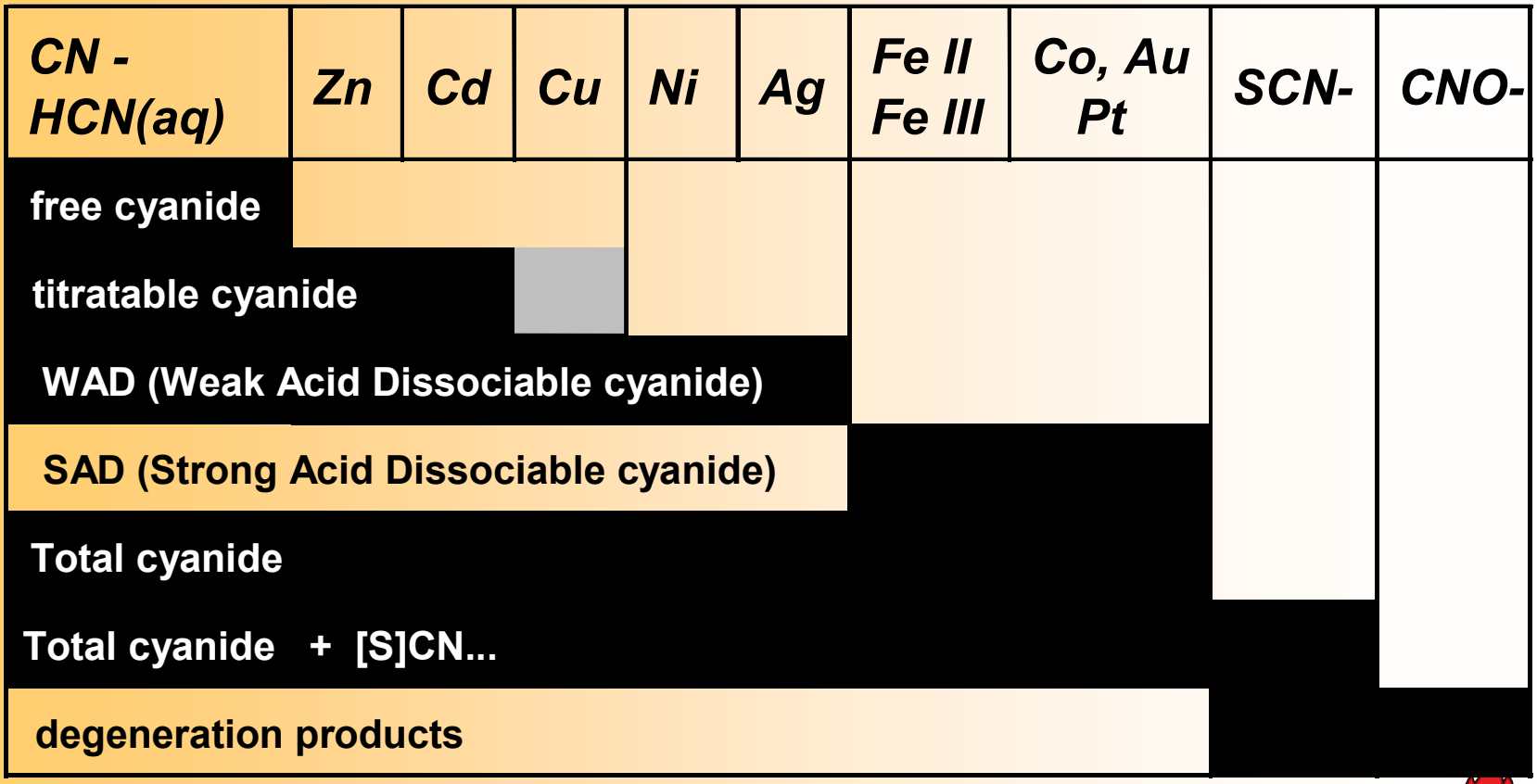


$S^{2-} \rightarrow SCN^-$

$O_2 \rightarrow CNO^-$

Who belongs to which family?

Species included in sum-parameter terms



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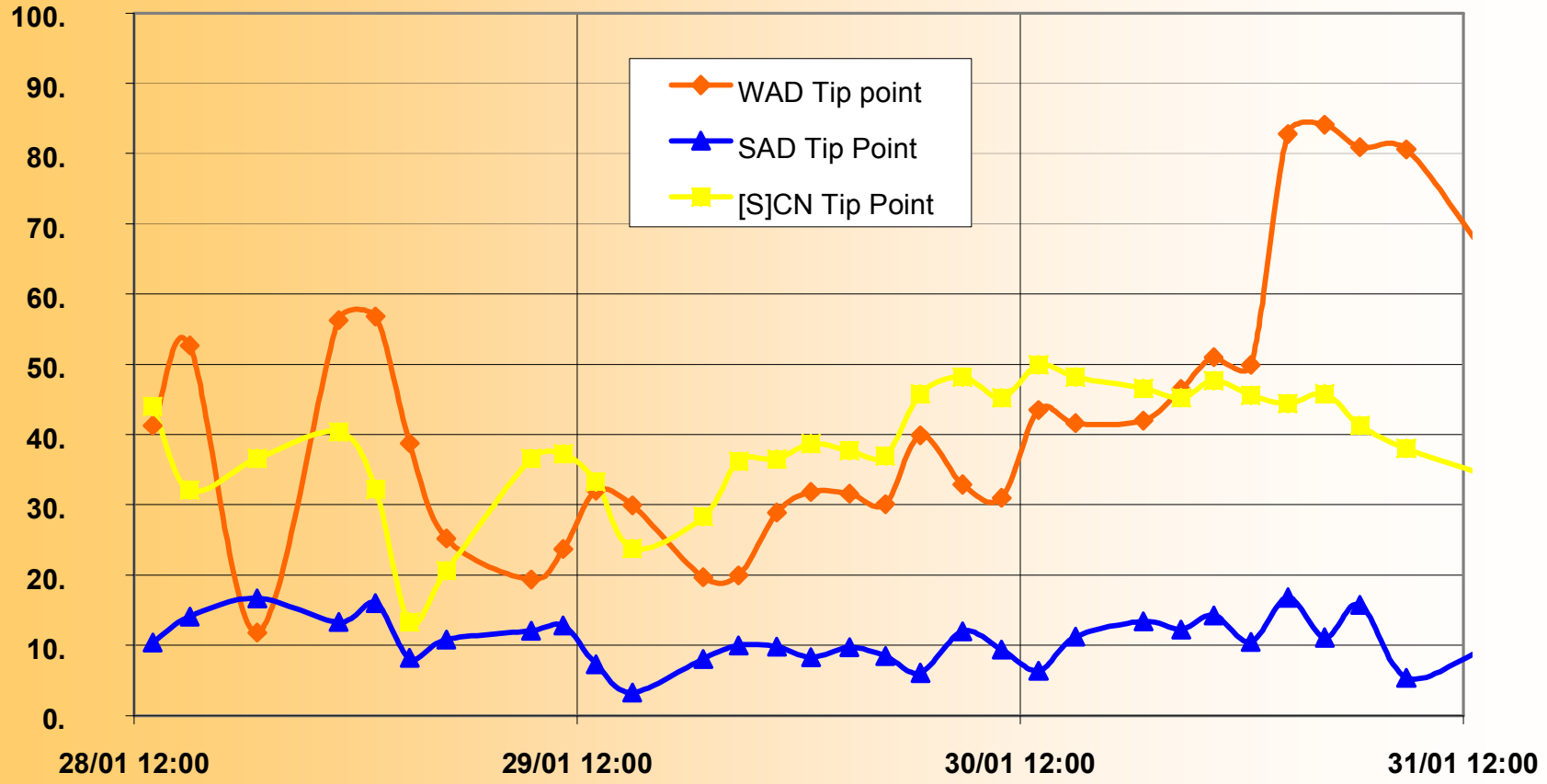
Example: CN Species and unstable plant

CN species discharged, in ppm - 3 x 24 h



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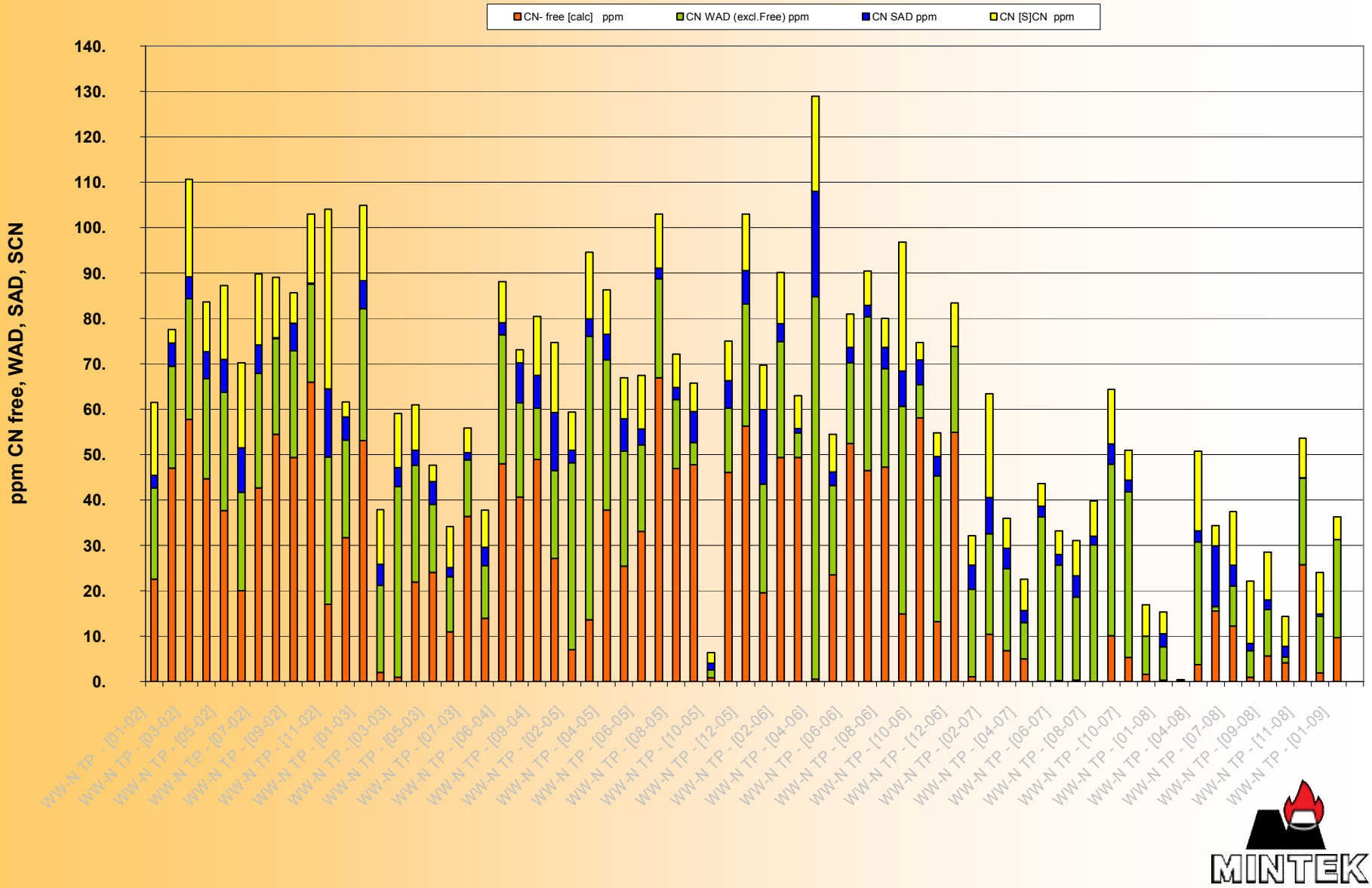
Example 2: CN Species discharge fluctuations



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What can be used to mitigate these risks?

1. Cyanide in-put reduction by using **automation and monitoring**
2. Use process **internal waste streams** (carbon wash acid, elution barren) cleverly to **control spikes, pH and HCN volatilization** (either encourage or suppress)
3. Know your **speciation with changing mineralogy** before the ore hits the agitator
4. Cyanide focused **audits based on ICMI** protocol
5. Practice any **emergency procedure** before it is actually needed, verify all chains of command

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Physical risks… reduction measures

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Chemical risks… reduction measures

A sea container in Australia, loaded with 16 tons of highly toxic sodium cyanide, was trucked through the city of Perth after a transportation bungle... The dangerous chemical was carted by Australian Gold Reagents from Kwinana to a yard in Bayswater on August 4 in a container that should have been empty. The blunder was discovered after a forklift was unable to lift the container off its trailer. A report by AGR said the incident was serious and the Bayswater yard was not on a dangerous-goods route. Sodium cyanide, widely used by the mining industry to extract gold from ore, is a poisonous chemical that can cause death if swallowed.

- "Toxic Cargo Trucked into City," The Sunday Times,30 September 2006.

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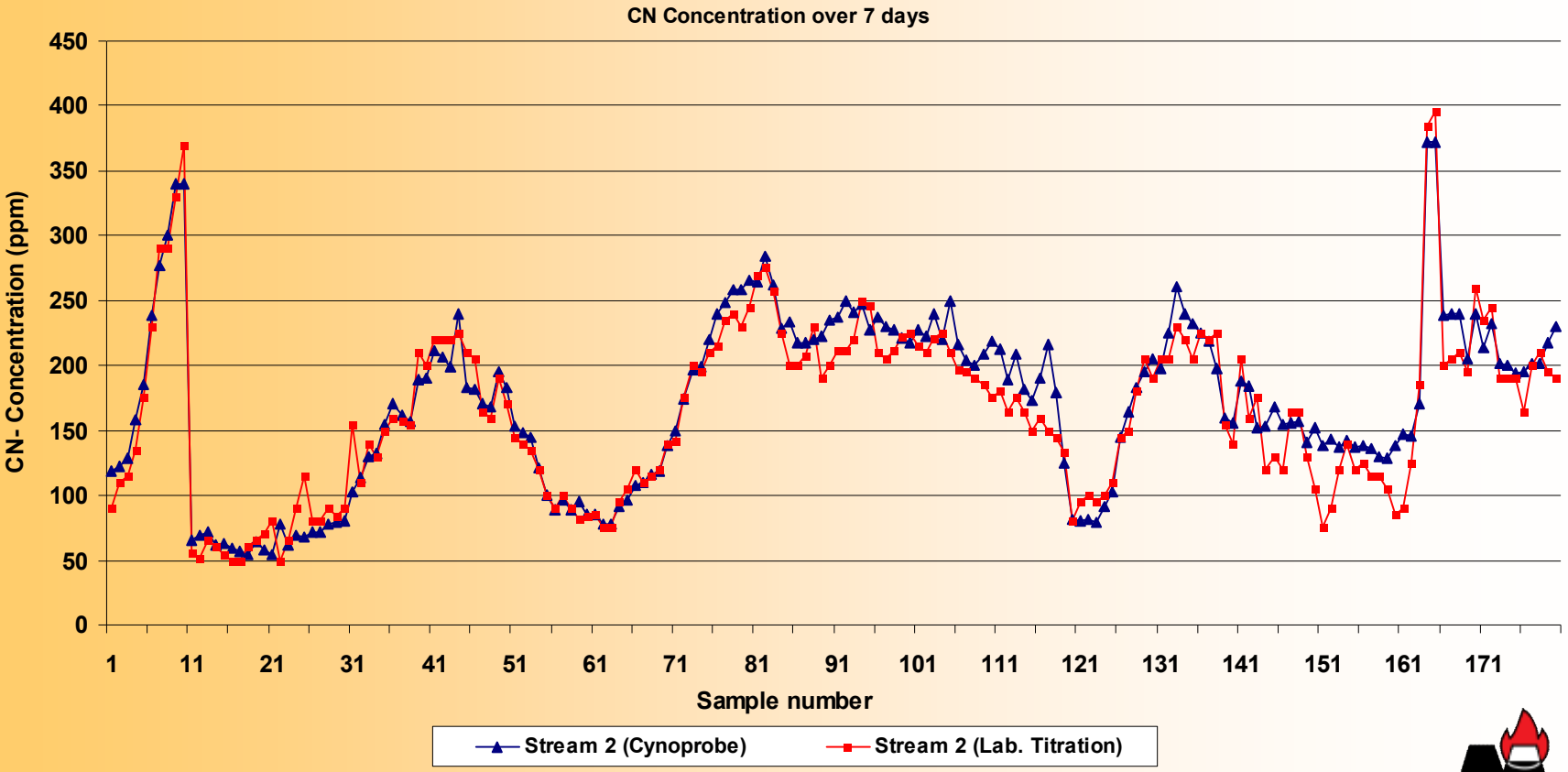
Chemical risks… reduction measures

Track the cyanide and question the need and reason for excess addition



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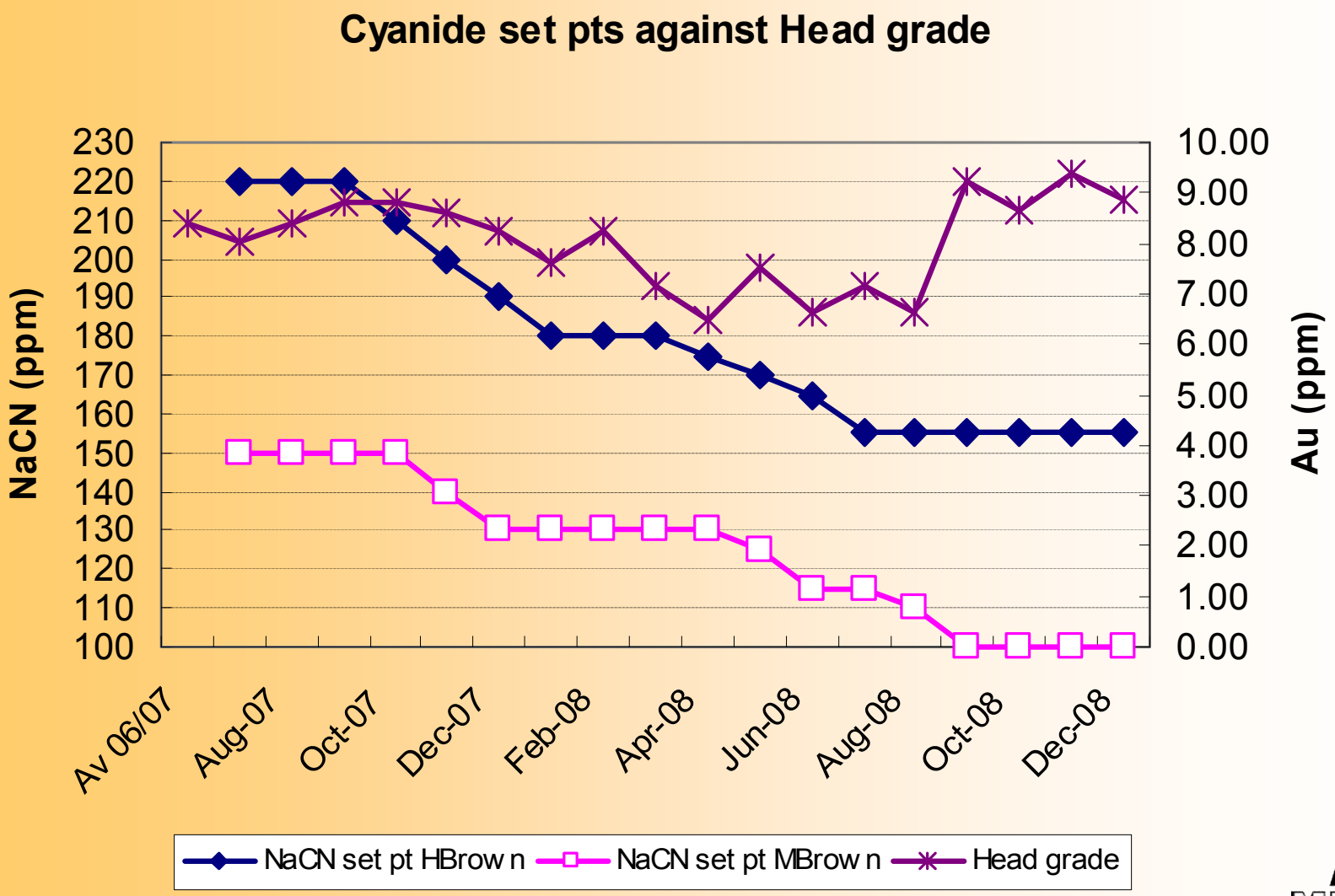
Lowering of risk:

Stepwise reduction of NaCN addition set-point



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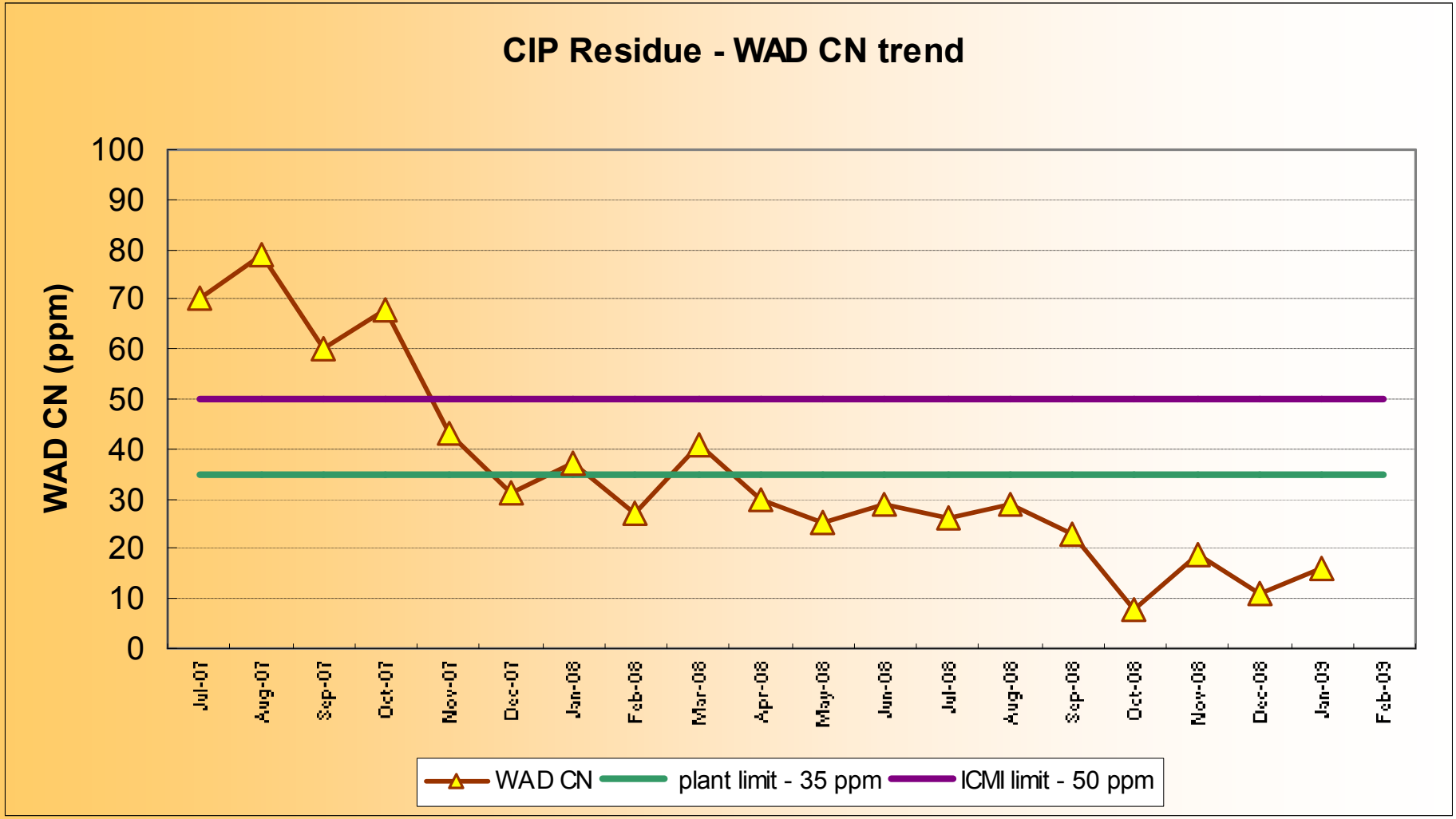
Lowering of risk:



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So, what tools do we have at our disposal?

- **Site knowledge** and **sampling** strategies
- **CN analysis (to ISO 17025) and speciation** including CNO and SCN
- **CN** deportation as **solid phases** (Prussian Blue)
- Hence **CN mass balance** (using volatilization models etc)
- **CN "experimentals"**: carbon assessment, conventional and advanced leach tests (all parameters monitored)
- **CN destruction** as a last resort (all methods)
- **ICMI audits** to capture the site management risks
- **On-line monitoring instruments** (free, WAD)
- **Plant control systems** (MaC: LeachStar etc)
- **Multi-disciplinary teams** covering mineralogy, hydrometallurgy, measurement & control as well as specific suppliers to the industry (oxygen, instrumentation etc)

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The ICMI code: (don't we all love audits?)

1. PRODUCTION: Encourage responsible cyanide manufacturing by purchasing from manufacturers that operate in a safe and environmentally protective manner
2. TRANSPORTATION: Protect communities and the environment during cyanide transport
3. HANDLING AND STORAGE: Protect workers and the environment during cyanide handling and storage.
4. OPERATIONS: Manage cyanide process solutions and waste streams to protect human health and the environment.
5. DECOMMISSIONING: Protect communities and the environment from cyanide through development and implementation of decommissioning plans for cyanide facilities.
6. WORKER SAFETY: Protect workers' health and safety from exposure to cyanide.
7. EMERGENCY RESPONSE: Protect communities and the environment through the development of emergency response strategies and capabilities.
8. TRAINING: Train workers and emergency response personnel to manage cyanide in a safe and environmentally protective manner.
9. DIALOGUE: Engage in public consultation and disclosure.

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Main Elements of the Code Structure:

Principles, Standards, Clauses…

Example: "secondary containments"

1. OPERATIONS: Design, construct and operate cyanide production facilities to prevent release of cyanide.

1.1 Production Practice: Design and construct cyanide production facilities consistent with sound, accepted engineering practices and quality control/quality assurance procedures.

1.1. 7. Are **secondary containments for process and storage tanks** and containers **constructed of materials that provide a competent barrier** to leakage and **sized to hold a volume greater than that of the largest tank** or container within the containment and any **piping draining back** to the tank, and with **additional capacity for the design storm event** (if applicable)?

Each of these clauses (205 Au mine, 110 CN Production, 67 CN Transport) demands positive confirmation (no "sampling") and, for full ICMI compliance audits, reporting of the observed evidence (SOPs, design plans, physical observations, interviews etc)

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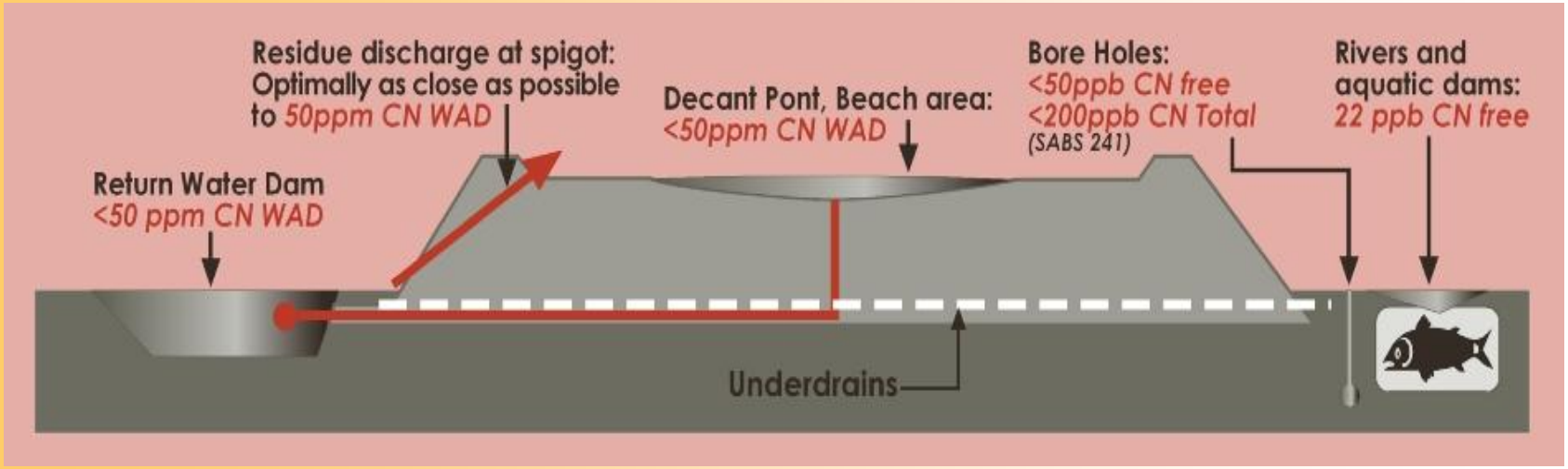
The ICMI code: the few numericals contained…

Rule: where national legislation does not exist or are less stringent than the ICMI, the code numericals apply

(effluents prior discharge: <0.5 ppm CN WAD)



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ICMI Signatories

Au mines (20), CN producers 12) and CN transporters (17)

Gold mining corporations signed up

- **AngloGold Ashanti, South Africa**
- Aruntani SAC, Peru
- Barrick Gold Corporation, Canada
- Centerra Gold Inc., Canada
- Dundee Precious Metals Inc., Canada
- Elk City Mining LLC, United States
- Gabriel Resources Ltd., Canada
- Goldcorp Inc., Canada
- **Gold Fields Limited, South Africa**
- Golden Star Resources Ltd., United States
- **Harmony Gold Mining Company Ltd, South Africa**
- Kingsgate Consolidated Limited, Australia
- Kinross Gold Corporation, Canada
- Minera Penmont S de R.L. de C.V., Mexico
- Newcrest Mining Ltd, Australia
- Newmont Mining Corporation, United States
- PanAust Limited, Australia
- Petaquilla Gold S.A., Panama
- Rio Tinto, United Kingdom
- Yamana Gold Inc., Canada

Cyanide Producers

- Anhui Anqing Shuguang Chemical Co., Ltd, P.R. China
- Asahi Kasei Chemicals Corporation, Japan
- Australian Gold Reagents Pty Ltd., Australia
- CYANCO, United States
- CyPlus, Germany
- E.I. DuPont de Nemours and Company, United States
- Lucebni zavody Draslovka a.s. Kolin, Czech Republic
- Orica Australia Pty Ltd., Australia
- Proquigel Química S/A, Brazil
- **Sasol Polymers, South Africa**
- TaeKwang Industrial Co., Ltd., South Korea
- Tongsuh Petrochemical Corporation, Ltd., South Korea

Cyanide Transporters

- Allship Logistics Limited, Ghana
- Australian Gold Reagents Pty Ltd., Australia
- Barbex Technical Services Limited, Ghana
- Bollore Africa Logistics, France
- Centerra Gold Inc., Canada
- Concordia Transportes Rodoviários Ltda., Brazil
- Freight Forwarders Kenya Limited, Kenya
- Freight Forwarders Tanzania Limited, Tanzania
- Innova Andina S.A., Peru
- Miller Transporters, Inc., United States
- **Sasol Infrachem, South Africa**
- Sentinel Transportation, LLC, United States
- Tamse Consultores Asociados S.A.C., Peru
- Transport Terrassement Minier, Republic of Guinea
- Transportes Niquini Ltda., Brazil
- TransWood Inc., United States
- Vehrad Transport and Haulage Limited, Ghana

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Taking bets on the future?

- Link metallurgy and environment
- Re-assess all times (self audits and third party)
- Monitor for up-dated regulation and code issues etc, preferably in advance
- Maintain (plant, water balances, PIDs) - don't let it slip
- Train, don't loose skills (what is the average age of your key staff?)
- Maximize value and integrate water balance, CN, As, Au etc

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Thank you, Questions?

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