The purpose of this summary is to technically respond to the water stakeholder comments received by Park City Municipal Corporation (PCMC) on the constructed wetland proposal which was presented to the Silver Creek Stakeholder Group by Dr. Fitch on January 13th 2006.

During the month of February, PCMC received comments from the Bureau of Land Management (BLM), U.S. Fish and Wildlife Service (FWS), as well as David Reisman, Dan Wall, and Brian Caruso all representing the United States Environmental Protection Agency (USEPA). The format of this correspondence is divided by each respondent and will address the comments expressed by the stakeholders. Dr. Fitch's response to the respondents has been included in this document and the question will be identified as a bullet and his response denoted as "UMR".

Bureau of Land Management (BLM)

The BLM represented by Glenn Carpenter (Field Office Manager) reserved official comment on the proposal since the Phase I project resides on PCMC property. Secondly, Mr. Carpenter reiterated that in the event PCMC in the future would need to expand the biocell onto BLM property, the City would need to submit a "formal perfected application". Mr. Carpenter implied in his correspondence that for the project to be successful Phase II and III would need to be constructed. PCMC would disagree, as Dr. Fitch conveyed during the stakeholder meeting the proposed Phase I area is adequate to substantially reduce the zinc and cadmium load from the Prospector Drain. Since the City has always been supportive of the watershed stakeholder approach Phase II and III were proposed as an opportunity for BLM as a stakeholder to participate with this project. However, BLM has not now, or in the past expressed that same mutual desire; therefore if the City ever moves forward with this project the focus will be Phase I.

Lastly, BLM concluded with the correspondence inquiring into the ownership of the drain and if the City is "disclaiming any interests or ownership in the drain". Mr. Carpenter continues that if PCMC does not own the drain, the City would not oppose BLM exercising authority under CERCLA to "insure cessation of the discharge". PCMC is puzzled by such a statement; the City has never inferred that the drain was constructed as a public works improvement or constructed with public funds. In addition, PCMC has never operated as a mine company thereby being the generator of the waste that impacts that water conveyed from the Prospector Drain (PD). That the drain is constructed through PCMC property does not in fact constitute ownership and the City would disagree with such a premise. PCMC continues to believe that BLM funds would be better spent working towards a common remediation goal than navigating the CERCLA option. Such a position does not coincide with the following Upper Silver Creek Stakeholder goal:

"Achieve regulatory closure and minimize the need for future Federal/State involvement, especially with regards to CERCLA (aka Superfund). Remove existing sites from the CERCLA database as appropriate and minimize the need for addition of other sites into the database, if appropriate. "

The City believes the above addresses the major comments within the BLM response that have not already been the subject of past correspondences.

United State Department of the Interior – Fish and Wildlife Service (FWS)

PCMC received comments from the Fish and Wildlife Service Utah Field Supervisor Henry Maddux. The FWS recognized the current constructed wetland proposal as an opportunity to treat water originating from the PD in a manner that improves water quality within Silver Creek, while at the same time restoring natural resources.

The FWS essentially had six primary technical concerns identified as operation and maintenance, flow-paths, management of overflow volumes, control of run-on, "take down" maintenance, and reducing the metals to the proposed Total Maximum Daily Load standard (0.39 mg/L zinc and 0.00075 mg/L cadmium). Regarding the operation and maintenance of the unit, Dr. Fitch conveyed during his presentation to the stakeholder group the wetland will be designed to accommodate easy access for maintenance. The spacing of gravel trenches is such that a typical construction vehicle (namely a backhoe or small trackhoe) can drive on top of the gravel trenches in order to navigate to any point in the wetland and repair. The wide distribution and collection channels were sized to minimized head loss through these channels for the total anticipated flow.

The FWS inquired into how flow paths will be established; the current proposal specifies the installation of perforated PVC pipe to direct water flow within the unit. Also, the pipe will be of a sufficient schedule (wall thickness) to withstand three foot of gravel atop the pipe while also having perforations (holes) sufficient for free flow of water out at any point along the length of the wetland. Regarding the premise of "short circuiting" the unit will be monitored and upon discovery the area will be repaired or flow adjusted to prohibit such an event. The FWS also requested how a "bypass" event will be handled in the event the wetland treatment area cannot handle introduced flow. PCMC had proposed a vault situated at the entry point of the wetland. The vault would have two valves one that feeds the wetland cell and the other would be considered a bypass valve which would be used if the wetland capacity was breached. PCMC anticipated the development of an operational manual as experience is acquired on how the unit performs during seasonal fluctuations.

The FWS also requested information on how "overland run on" will be managed and controlled. Regarding surface flow, the berm situated on the south side of the unit currently prohibits any surface water from entering the wetland cell. Lastly, the area does back up with water, however to prohibit this influence the design specified a berm on the east side of the unit for the purpose of containment.

FWS also requested information on how the unit would be "taken down". Based on the Nature Works Representatives and Dr. Fitch the City does not believe that such a scenario will be the case for many years. However, in the event this was the case, the wetland was designed in a manner where this could be done in stages with adequate equipment.

The FWS inquired into how effective the unit will be in reducing metals concentrations to the TMDL effluent limits and ambient water quality criteria. This issue is addressed in this response and has been given a separate section since it was also conveyed by USEPA respondents. The FWS maintains that the proposed wetland may not result in achieving water quality standards. Mr. Maddux goes on to question the issue of the tailings underlying Prospector Square. FWS suggested that the PD is but one of the several pathways that transport contaminants and that it would be helpful to know more about the hydrologic connections within the watershed. PCMC would disagree that further study needs to be conducted and would recommend that the FWS review Kenneth E. Kolm and Y. Eugene Yan (Argonne National Laboratory) report titled "QuickSite Investigation for the Upper Silver Creek Watershed, Utah: Regional Analysis and Recommendations (2003)". This USEPA sponsored report characterized the hydrologic system of the upper Silver Creek watershed with respect to both surface and groundwater subsystems. Additionally, PCMC has invested a substantial amount of public funds for an inline flow meter and monthly sampling of the PD and as result the City is now in a position to treat a source for zinc and cadmium within the watershed. FWS expressed a desire to discover other pathways of water movement through the system. If FWS would like to invest in such a study, PCMC is supportive of the desire; however, this proposal is specific for the water that originates from the PD which does have supporting flow and analytical data. Also inferred by FWS was that the City did not investigate other feasible treatment options, when in fact other options were investigated and were discussed during the

stakeholders meeting. PCMC worked with the National Energy Technology Laboratory (Terry Ackman, Clean Water Treatment) in 2003 to investigate the feasibility of an in-line treatment patent. However, in addition to operational concerns, chemical costs, maintenance and neighbored intrusiveness it was deemed not feasible. Reverse osmosis was also investigated; although effective the costs of such a unit was prohibitive. Lastly, Dr. Fitch within his presentation stated the options quite clearly along with the specific pros and cons. FWS theorized that options such as lining the Silver Creek could potentially reduce the flow; although PCMC agrees the City has procured PD flow data for 27 months and based on Dr. Fitch's design the flows can be managed in the designated area. Lastly, if FWS would like to pursue this option PCMC believes that the affected Prospector Square private property landowners (34) and Utah State Parks (Rail Trail) should be consulted before planning such intrusion into backyard improvements.

The FWS questioned the stormwater management in Prospector Square, specifically "run-on controls", drainage management, and diversion. The majority of Prospector Square is capped with hard paved roads, curb and gutter, permanent structures (foundation, house), driveways, or 6" of clean top soil substrate, protected by acceptable cover. All of these improvements impede or influence the percolation of storm water migrating into the underlying tailings.

The FWS stated that the project would trigger Section 404 of the Clean Water Act. PCMC on January 23 2006 submitted a Nationwide Permit Application #39 to the Army Corp and was granted approval on February 1st 2006.

Lastly, the FWS closed by stating that the Service supports a "maximum feasibly achievable reduction" in the contaminant loading in Silver Creek. This was also PCMC ultimate goal with the bio-cell proposal and the City believes that Dr. Fitch and the Nature Works representative have the expertise to see this project succeed.

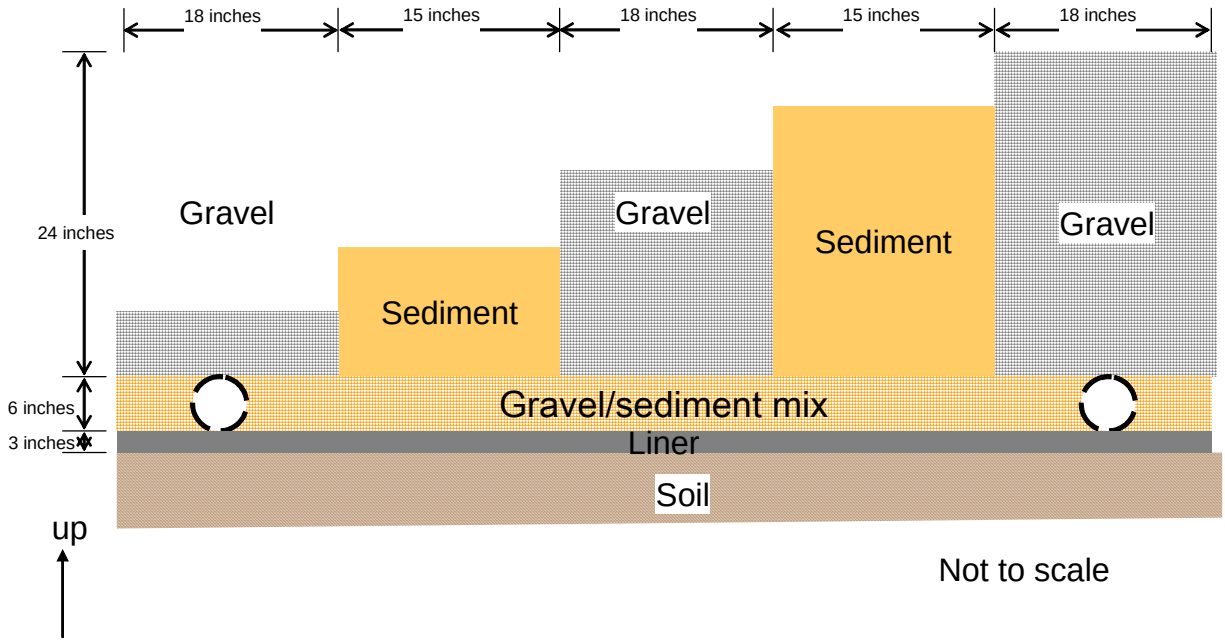
UMR

I wanted to note that I enjoyed the thoughts shared and questions asked by the FWS representative at the stakeholders meeting at which the design was presented. Many of the written comments seemed to me to be addressing larger watershed issues rather than the design.

- Feasibility in terms of construction and operation & maintenance, with specific questions about how the alternating layers of gravel and active biological "substrate" will be laid down.

UMR

The suggested construction method is to lay down a short lift, 4-6 inches deep, illustrated below. During construction, the various levels will be ziggurat-like, and strings can mark the edges of each lift/layer. A skid loader or small dozer (something with a 5-6 foot reach with a bucket) can pour the material (gravel or mixed substrate) onto the layer followed by manual dress up to roughly level that layer. The individual lifts will slump only a small amount because the exposed height is only a few inches.



- How flow paths within the wetland will be established and maintained, and how "short-circuits" (when the water takes a flow path around the substrate treatment cells) will be identified and repaired.

UMR

Short circuiting has been addressed in the attached comments see #3 and #18.

- How overflow volumes will be dealt with.

UMR

The inlet structure is to have a bypass to the existing drain/outfall.

- How the unit will be "taken down" for maintenance (i.e., will the whole system have to be taken off-line, with untreated water going into the creek, in order to perform maintenance, and if so, for what length of time).

UMR

The expectation is that most maintenance can be done without diversion. Eventually some major maintenance will be required (best case – pipes will fail after some number of decades) and major portions of the cell will have to be excavated and rebuilt, which I believe will require weeks. If additional cells are constructed, the bypass can go to those downstream cells, mitigating the impact of one cell going off-line.

- The proposal's contention that "Limited measurements from wetlands receiving and discharging higher concentrations have shown negligible effluent toxicity" references direct acute toxicity …

not necessarily … chronic toxicity …, nor, importantly, does it address the issue of zinc or cadmium loading and accumulation in sediments downstream.

UMR

Agreed; I apologize that my wording was not more specific. I would note that our WET tests used not fathead minnows but C. dubia, which I believe are considered to be more sensitive organisms to direct toxicity. It seems to me to be reasonable to expect that a decrease in the metals load to the creek should decrease any putative toxic effects, but I am not a toxicologist nor in any way familiar with the specific food web of the creek.

- In general, the Service does not approve of the use of natural wetlands for water treatment. In this case, an absence of an evaluation of other treatment alternatives (or ways to minimize the amount of wetlands needed for treatment) would make it more difficult for the Service to approve this approach.

UMR

Other treatment alternatives were considered and listed in both of the presentations I gave at Park City. I believe the wetlands are the least-cost treatment technology.

United States Environmental Protection Agency (USEPA)

The following is to address the comments made by USEPA representatives David Reisman, Dan Wall, and Brian Caruso:

- **Dr. David Reisman, Director ORD Eng. Technical Support Center**

PCMC acknowledged Mr. Reisman's opinion that water should be fully characterized before constructing such a wetland. He went on to state that he was not given such analyses, however PCMC provided USEPA with all of the analytical data up to the most recent stakeholder meeting. However, in the event USEPA would like another copy, the City would be willing to accommodate such a request and Dr. Fitch's response reproduces a summary table from his original white paper.

UMR

It was apparent that several reviewers were not familiar with the specifics of the water to be treated; I had incorrectly assumed the stake holders knew the specifics in this case. Particularly relevant in Table 1 at right is that pH is 6.2 on average, such that I would say this is not an acid mine drainage, but rather a neutral metal-tainted water. The concentration of dissolved metals is low when compared to acid mine drainage, 7 mg Zn/L, 0.04 mg Cd/L and 0.3 mg Fe/L. The hardness is very high and sulfate is significant. Note that the iron is low enough that iron oxyhydroxide formation will be very slight and minimal armoring of solid surfaces is expected.

Table 1. Water Composition

	Mean	St. Dev
pH	6.2	0.3
TSS (mg/L)	3.6	3.6
TDS (mg/L)	1770	205
Hardness (mg/L)	910	125
DO (mg/L)	6.0	1.0
Sulfate (mg/L)	650	50
As (mg/L)	0.001*	0.0003
Cd (mg/L)	0.04	0.01
Fe (mg/L)	0.21	0.26
Hg (mg/L)	BDL	
Pb (mg/L)	0.02*	0.04
Zn (mg/L)	6.8	2.3

Based on data provided by PCMC.
BDL = Below detection limit.
* Many values were below detection limit.

- Mr. Reisman within his comments expressed the USEPA desire to see this unit comply with the proposed TMDL standards for Silver Creek. PCMC has reserved addressing this topic later in this document; however the foundation of the City's position is that the proposed TMDL effluent standard is unachievable and not practical.

UMR

The design was not based on meeting a proposed effluent standard, rather on substantially reducing the metal load due to the Prospector outfall. This proposed cell is envisaged as the first of two or three, with subsequent units being larger; however, I believe the authority over the areas that would serve well is currently not PCMC. I feel obligated to leave addressing these issues to the City (UMR).

The City views the biocell as a component of a systematic watershed approach to address point source, non-point source, and naturally occurring background levels and pursues the TMDL reduction goal of reducing zinc by 65% and cadmium 92%. PCMC takes exception that the stakeholder group completely ignores other efforts by the City related to the implementation and investment of institutional and engineering controls that also influence the metal load to Silver Creek, thereby also influencing the TMDL annual reduction goals. The City's main intent with the biocell project is to pursue the objective of the annual watershed reduction goals defined within the proposed TMDL. Also expressed by Mr. Reisman was that the stakeholders or Park City may not agree on viewing this unit as a research demonstration project. The City does not believe USEPA, UDEQ, or other stakeholders have all of the answers in regards to the effectiveness of constructed wetlands treatment systems. Furthermore, the City believes this project would have expanded the knowledge base related to constructed wetlands and if successful would have applicability to other areas of the watershed as well as other western states with similar environmental challenges. Because there is a lack of experience in this area the City has no reservations in calling this a research project coordinated by Dr. Fitch with the University of Missouri Rolla.

UMR

To my knowledge, nobody has built a full-scale horizontal-flow system as proposed, on a relatively thin strip of organic-rich substrate, but a significant number of vertical-flow systems exist. Being first in

engineering solutions is sometimes considered to be "the bleeding edge" of progress. The horizontal flow system does offer advantages in terms of controlled flow and access to selected parts of the substrate. My understanding is that no vertical-flow system has run more than five or six years without requiring a complete rebuild, and thus the promise of the horizontal-flow system as proposed is being able to do maintenance at a small scale. If a short-circuit develops, tracer tests using samplers across the wetland can isolate the area of the failure, and substrate can be added at that location and compacted to decrease the short-circuiting.

- Reservations were also conveyed related to the proposed substrate and Dr. Fitch offers the following:

UMR

The proposed design includes that maintenance and monitoring are necessary. The organic will decay, with replenishment at some rate by senescent plant matter. Depending on relative rates, the organic content might increase or might decrease. Therefore, if sulfate removal decreases (reflecting a decline in organic), fresh media shall be added. I find the idea of a permanent treatment process troubling; given that 20-year design lives are standard in engineering, I would think very few treatment processes can be considered as permanent.

The specification of a low lignin wood as the organic was the result of a suggestion that some of the locally available woody materials are fairly non-biodegradable (i.e. Douglas fir, a redwood-like material).

- Dr. Reisman stated that "The pilot scale results shown in the graph of the PowerPoint presentation show zinc removal seldom exceeding 60 %. We have an existing wetlands-bioreactor that eliminates zinc at greater than 95 %, and has done it during the warmer months for approximately 3 years."

UMR

I suspect that a detailed comparison would show that the EPA reactor has a longer residence time/lower loading rate and possibly a higher concentration of Zn. Higher concentrations give better % removal, as do longer residence times. Therefore one might ask: shouldn't this system thus have a longer residence time? Ideally, the proposed bioreactor (aka constructed wetlands in my opinion) is the first treatment cell. Additional treatment is dependent on demonstrated success of the first cell and availability of both suitable a site and resources for construction. Additional wetland cells will give longer residence times and greater removal.

- Dr. Reisman in regards to the use of manures states "they will add manure to provide carbon while the wood chips are decomposing. There is very little data to show that this will work, and for how long ... In fact, adding manure may introduce other bacteria that may interfere with the existing microbiological structure."

UMR

The large fraction of manure was based on the suggestion of the third-party reviewers who were concerned about kick-starting the system. Although I am confident that the proposed mixture will work, a pilot test of the proposed mixture might be good. I strongly disagree that other bacteria would be introduced that interfere. The manure is the microbial inoculum. Coming from cattle, the manure will

include cellulosic degraders and sulfate-reducing bacteria. I found in researching this response that cow manure was recommended as an optimal substrate for metal-treating bioreactors by a study funded as part of EPA's Mine Waste Technology Research (Activity III, Project 24).

- Dr. Reisman states "The microbiological community must be developed and include other functional bacteria, such as fermenters, degraders, and "cellulose providers." Several years ago, two other researchers in this area, Dr. Miller and Dr. Tsukamoto from the University of Nevada-Reno, stopped working on a bioreactor of wood chips and manure similar to what this proposal is trying to achieve."

UMR

My impression, based on their Water Research publication, was that these investigators were using wood chips as a solid matrix and supplementing with alcohol, and I gather they are doing something similar at the Leviathan Mine; I'd appreciate knowing where they published the failure that is alluded to. In contrast to their results, our lab-scale reactors have operated for six years on the original substrate mixture of wood chips, sand, manure, straw, sludge, and gravel. We seem to have large numbers of SRBs (not measured since 2001, but apparent in sulfate reduction and sulfide production). The wood chips seem to continue to degrade with a low rate of organic utilization. One of my students just determined (handed me his document an hour ago as I write this!) that the six-year old wetland shows an organic decomposition rate of 0.04 mg VS/g original TS/day, while brand-new wetlands have a rate of 0.09 mg VS/g original TS/day. This would indicate exhaustion at about 30 years. Perhaps as the reviewer suggested the pH makes a huge difference in our results vs. Drs. Miller's and Tsukamoto's.

- The comments also stated that "Other issues with this substrate that might occur: varying rates of decomposition, non-homogeneous mixtures and decomposition, eventual preferential flow, compacting, clogging, precipitation and lodging on the bottom of the reactor."

UMR

The proposed design specifies that the substrate must be well-mixed to avoid issues of non-homogeneity, and preferential flow (short circuiting) and compaction (which would result in surface subsidence) must be monitored. I don't understand what is meant by 'precipitation' in the above, perhaps that organics will precipitate out in the gravel layer? Such will occur, and would result eventually in excessive head loss and preferential flow to a non-clogged location.

- The comments include; "Will Dr. Fitch be able to denote this event [cellulose limitation] in your reactor prior to failure (i.e., lack of the right form of the food from the substrate)?"

UMR

Eventually something will fail and the system will require maintenance. If the hydraulic elements (pipes, pump,, valves, berms) don't fail, then most likely the organic will become depleted. The proposed design does not suggest monitoring the volatile solids, which in the long term may be an oversight. As the organic (electron donor) is depleted, the rate of electron acceptance will decrease, and as a result the reduction of sulfate will decrease. Thus regular monitoring of the decrease in sulfate across the bioreactor should show when the rate of electron donation slows and available organic is depleted, assuming that plants do not replenish the organic at a greater rate. Park City might also annually sample some of the substrate and determine volatile solids to monitor the (presumed) decline in organics.

- The comments also recommended the use of limestone rock, a source for this product has been found and were part of the design. A settling pond was also added to the design and is situated at the end of the unit.

- Dr. Reisman stated that "As far as the plants dying and adding organics to the reactor, we have seen little data on this development and would like to see the references that provide this data."

UMR

I admit it has been an assumption that when the plants growing in the wetlands become senescent at wintertime the dead plant mass will fall to the sediment surface and decay. I also have assumed that growth and any death of rhizomes result in net organic addition to the substrate (sediment). We have not carried out long-term studies of organic content in planted vs. non-planted reactors to determine how much organic deposition, if any, occurs.

- Also stated, "In certain areas of the proposal, I was confused as to whether the system would be anaerobic or aerobic."

UMR

The substrate itself will be anaerobic aside from the top few millimeters of the saturated substrate and the front few millimeters where water flows in. The influent gravel zone I expect to be aerobic (the influent water has a moderate DO) and the effluent gravel zone may become aerobic.

- Dr. Reisman suggested the construction of sampling ports at the various levels of the reactor in different places. Dr. Fitch included sampling tubes in the draft final design but not in great detail.

- Dr. Reisman suggested looking at other metal concentrations.

UMR

The data provided by PCMC, monthly monitoring reports of the outfall, is summarized above in Table 1. I do not have data about aluminum, but I suspect there is very little in the water.

- Dr. Reisman states "In our recent study, we found that the bugs did not "use or like" the sand as a media. It will also affect the hydraulic conductivity in this project."

UMR

The sand is to be well-mixed in with the other substrate components as a solid, high-permeability component to help limit compaction and increase permeability. I do not have proof that sand performs these functions in the substrate, but I understand sand does perform such functions in soils.

- The comments conclude that "Eventually, the proposed reactor will become more compacted (after 5 years or so). ... Short-circuiting will come into play, and may cause part of the system to become aerobic unless many dollars are spent to tear apart and re-build parts of the reactor."

UMR

The issue of compaction and short-circuiting is indeed a concern and I believe a frequent cause of problems in vertical-flow wetlands. The periodic tracer tests recommended in the design should be analyzed to show changes in hydraulic conductivity, and locations with higher conductivity can have substrate added from the top and be compacted slightly to decrease the conductivity. Unfortunately, the utility of such an approach has not been, and possibly cannot be shown conclusively at lab-scale or at modest pilot-scale, and so it is a reasonable idea rather than a proven maintenance technique.

- **Dr. Brian Caruso, USEPA ORD Hazardous Substance Technical Liaison**

PCMC received Dr. Caruso's comments and noticed that his evaluation was largely based on the assumption that the PD discharged acid mine drainage. This is not the case and PCMC believes that this assumption could have influenced his evaluation. Nonetheless, Dr. Fitch has addressed the comments contained in his response:

- Vertical flow SRBs are generally regarded as more effective with less potential short-circuiting than horizontal flow reactors, if designed and operated properly. We believe that the basis for selecting a horizontal flow reactor is flawed.

UMR

I am not aware of studies showing Dr. Caruso's claim that horizontal-flow systems have more short-circuiting than vertical-flow systems. I suspect that the orientation of flow to the gravity field has little to do with short-circuiting.

- The cost of the additional flow distribution and collection piping required for vertical flow would be less than the cost of the gravel proposed in the current design, and the reactor would achieve greater metals removal efficiency with less short circuiting.

UMR

I don't agree on cost: a similar amount of gravel would be required to overlay the additional pipes and assure good vertical distribution, and I believe a layer of gravel on the top would be needed to prevent flotation. The costs are likely similar. All this would indeed provide more substrate volume and thus more treatment. However, my understanding is that maintenance on vertical-flow systems is to completely reconstruct the cell, whereas I believe the horizontal-flow system as proposed allows for small fixes because the substrate is directly available.

- Dr. Caruso writes "…gravel is not needed and may provide too coarse a material and too much porosity for precipitated metal sulfides, thereby allowing colloidal precipitates to flow through and exit the system to Silver Creek."

UMR

Gravel, or some other highly permeable material, is needed to distribute flow evenly across the site. The sulfides will be generated in the substrate and are expected to be retained in the substrate rather than the gravel. Colloidal material, particularly NOM, may indeed exit the system, and thus additional cells would improve further removal.

- It would probably be better to have 2 SRBs in parallel so that when one needed maintenance or repair, flow could be diverted through the other unit.

UMR

Agreed, but this assumes the unit needs to be shut down for maintenance rather than PCMC being able to add substrate at the surface. The ability to divert is planned at the inlet structure, but if only one cell is built, diversion would be directly to Silver Creek.

- The variability of seasonal and peak flow rates from the drain have not been adequately defined in the design proposal.

UMR

As noted in the general comments, I was surprised that the reviewers were not familiar with the situation. As reported by PCMC, the Prospector Drain produces 90 ± 15 gallons per minute regardless of season.

- In addition, flows and high water levels in Silver Creek, which is directly adjacent to the SRB site, have not been defined in the design proposal.

UMR

The issue of high water level and the berm height is well-noted. Anecdotal evidence is that high water levels don't exceed 1-2 foot below the proposed berm height. However, PCMC has been asked for further information on the maximum flood stage of Silver Creek.

- Within the comments Dr. Caruso stated that "Sewage sludge is not needed and could potentially add or release previously bound metals to the system." Based on PCMC reading of the proposal this type of inoculate was not proposed.

- Dr. Caruso states that "30% manure is too much and not needed."

UMR

Some evidence supporting this critique would be appreciated. As noted above, cow manure was recommended as an optimal substrate for metal-treating bioreactors by a study funded as part of EPA's Mine Waste Technology Research (Activity III, Project 24).

- Bark does not provide a good substrate or food source for the SRB and should not be used.

UMR

The SRBs that have been reducing sulfate for six years in my lab-scale chip bark-based bioreactors would be surprised. From a theory point of view, I don't know that anyone has isolated wood-degrading SRB, but this doesn't mean they cannot exist. More likely, though, and acceptable by bacteriologists, is that cellulose degraders produce organics which are used by SRBs.

- Vertical piping for sampling and flow and potential short-circuiting monitoring could introduce too much oxygen to the system preventing anaerobic conditions from developing in certain areas.

UMR

I disagree. The vertical piping, which will be small pipes widely separated across the wetland, should be water-filled and also loosely capped, limiting oxygen input to the top of the pipe and creating a stagnant water column. The diffusion rate of oxygen in water is low and no advection will occur, so I just can't believe this critique is correct.

- The metals removal rates achieved in the bench and pilot testing are relatively low. SRBs developed by EPA ORD can achieve >90 to 95% removal efficiency for most metals.

UMR

I believe that the ORD systems have lower hydraulic loading, treat higher metals concentrations (easier to hit higher % removal), 'benefit' from being acidic such that raising pH results in simple chemical precipitation, and remove iron as an oxyhydroxide which co-precipitates (or adsorbs) other multivalent cations. Additional cells will address the hydraulic loading, and PCMC is happy not to have the other factors in the water.

- EPA ORD and our Engineering Technical Support Center should work collaboratively with Park City and Dr. Fitch to modify and improve the SRB/wetlands design.

UMR

I think this is a lovely idea.

- **Dan Wall, USEPA**

A substantial fraction of Mr. Walls' comments concerned effluent quality.

- I support this effort but I think that the pilot wetland was only marginally successful. I think it would be prudent to see the pilot wetland be modified to approximate final biocell conditions and retested before significant money is spent.

UMR

This sounds wise to me. I am modestly concerned at changing slightly the design, particularly the substrate mixture, without a pilot test. I am also interested in a better-insulated and isolated pilot wetland outlet allowing for increased confidence in sampling during the winter. At the same time, the substrate composition is a slight change, and choosing to do additional pilot testing would almost certainly delay implementation of treatment by a year. It's a difficult choice, and I leave such a choice to the stakeholders and/or PCMC.

- Will the system of biocells be considered complete if the effluent standards are not met? Can the effluent standard be considered a performance criteria? What will be the measure of success of this system of biocells?

UMR

Although this comment partially concerns effluent standards, measures of success I will address in the negative: I would consider failure to be less than 50% removal of the zinc load (on an annual average) by this proposed first cell. Based on research at UMR, an outstanding success would be greater than 70% zinc removal. As to cadmium, 80% removal would be an outstanding success.

- I don't think there has been presented sufficient information that the wetland is functional in the winter. It appears that the biocell actually becomes a source when temperatures drop.

UMR

Jeff has stated that he believes the effluent samples were poorly obtained, which relates to my response to #38 (attached comments) additional pilot-scale testing should be better insulated and isolated from flooding. … wouldn't the Cd also have risen from contamination of the sample? Not necessarily, the Zn might be from the gravel itself (small particles), which might have much lower Cd content. Even if these possible excuses are correct, performance still was not as good as expected. As to winter, some biocells for AMD have been reported to give consistent good performance at very low temperatures, but others exhibit poor performance in winter. Such conflicting reports are quite irritating, and a better pilot effluent system run over another winter might establish the truth of the matter for this location.

Total Maximum Daily Load (TMDL)

On March 3rd 2004, PCMC submitted comments to John Whitehead who is the TMDL Project Manager for Silver Creek and represents the Utah Department of Environment Quality (UDEQ). Within those comments PCMC emphasized that the TMDL for Silver Creek watershed should be achievable for those stakeholders contributing to that water body. Furthermore PCMC questioned the designation of classifying Silver Creek as a "Class 3 A – Cold Water Fishery".

PCMC also took issue with the TMDL not factoring naturally occurring background levels when calculating the effluent limits within the TMDL. Referencing 40 CFR 130.2 (i), the federal definition of total maximum daily load (TMDL) is defined *as "The sum of the individual WLAs for point sources and LAs for nonpoint sources and natural background…"* . As stated in PCMC Silver Creek TMDL comments, naturally occurring zinc levels within soils have been found as high as 74 ppm (USGS). Because naturally occurring zinc levels were not considered in the TMDL that was submitted to USEPA, the City believes the proposed effluent limits within the TMDL are not complete and should be reevaluated factoring in background levels as required.

PCMC also requested that the TMDL factor in the actual hardness averages for calculating the zinc and cadmium chronic water quality standard. The City has supported UDEQ in pursuing grant funding to fund a Water Effect Ratio study to demonstrate the actual toxicity of the ambient hardness. Based on City hardness monitoring, the result is twice as much as what was used in the effluent limit calculation. PCMC recognizes that zinc and calcium carbonate (hardness) compete in regards effecting water toxicity, the hardness levels exhibited in Silver Creek are at levels that have the potential of displacing zinc thereby lowering the toxicity. As a result, PCMC believe the effluent limits should reflect the actual high hardness value exhibited in Silver Creek.

As a result, PCMC and UDEQ have the following agreement in regards to the Silver Creek TMDL:

To jointly pursue a process involving developing a supplemental study to investigate the following:

- Further examine the water chemistry (hardness, pH, etc.), fish, macro-invertebrates, and other related biota of Silver Creek to validate existing water quality standards or determine if a site specific water quality standard is appropriate for zinc and cadmium and what those standards should be.

- Attempt to determine "background" or "baseline" conditions that reflect water quality values with minimal or without human-induced impacts through supplemental monitoring and/or location of additional data.

- Evaluate the technical and economic feasibility of achieving water quality standards for zinc and cadmium, given the widespread historical mining impacts. This will include an investigation led by PCMC of treatability, along with associated costs, for metals of concern and identification of available funding sources for implementation.

Lastly, PCMC requested from the Division of Water Quality assurances that effluent limits for Silver Creek Watershed not be imposed until the additional study is complete and water quality standards for Silver Creek are either validated or revised based on the outcome of the study. UDEQ agreed that until the noted study has been completed, the division did not feel it would be appropriate to impose limits that would be dictated by current water quality standards that are included in the TMDL. Instead UDEQ and PCMC have a mutual agreement to work together to establish reasonable interim limits that recognize the uncertainties indicated in the submitted comments.